ANNALS

OF THE

CARNEGIE MUSEUM

VOL. XIII.

1919–1922

W. J. HOLLAND, *Editor*

PUBLISHED BY THE AUTHORITY OF THE
BOARD OF TRUSTEES OF THE CARNEGIE INSTITUTE
MARCH, 1922

PRESS OF
THE NEW ERA PRINTING COMPANY
LANCASTER, PA.

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ERRATA AND CORRIGENDA.

P. 39. Tenth and eleventh lines from top, and p. 40, twentieth line from top, for "*Opthalmolampis*" read *Ophthalmolampis*.

P. 84. Thirteenth line from bottom, for "Goglio-Tos" read Giglio-Tos.

P. 140. Second line from bottom, and p. 141, third line from top, for "*Homœogryllus*" read *Homœogryllus*.

P. 142. For "*Euscyrtus*" read *Euscirtus*.

P. 151. Third line from top, and p. 175, second and fourth lines from bottom, for "*Fusconaja*" read *Fusconaia*.

ANNALS

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VOLUME XIII, NOS. 1–2.

Editorial Notes.

In the present issue of the Annals there appear a few of the papers, which have been in the hands of the Editor for a considerable time, their publication having been unfortunately delayed for reasons already explained in the last volume and in the Report of the Director for the fiscal year extending from 1918–1919. We are happy in believing that the circumstances which brought about the delay in publishing these and other papers are not likely to arise again.

The death of Mr. Andrew Carnegie, which occurred on August 11th, 1919, at his summer home, Shadowbrook, Lenox, Massachusetts, removed the gracious presence of the Founder of the Museum, and inflicted an irreparable loss, for which his munificent provision through the Carnegie Corporation of New York to maintain the work he had begun, cannot atone. We shall miss his words of cheer and encouragement and the evidences of his appreciation unfailingly bestowed upon this department of the Institute, one of the very earliest of his great public foundations. Elsewhere in this volume the Editor, who for more than forty-five years enjoyed the close friendship of Mr. Carnegie, endeavors briefly to record some of his memories, especially those relating to the founding of the Museum and its subsequent work.

THE first Memoir to be included in Volume VIII of the Memoirs of the Carnegie Museum was issued in December, 1919. It is the final part of Dr. Arnold E. Ortmann's Monograph upon the Naiades of Pennsylvania.

The preparation of this work may be said to have been undertaken at "the eleventh hour." The great river-system of the Ohio arising in western Pennsylvania, western New York, and West Virginia, at the time of the first occupation of the region by the whites was rich in mollusca. In the process of time, with the great increase in population, which has occurred, and the huge development of industrial enterprises, which has taken place along the streams, these have become more or less polluted. The flow into the rivers of water strongly charged with sulphuric acid from the mines, the injection of waste from various manufactories, the disposal of sewage by drainage it into the streams, have gradually led to such contamination that the fluvial fauna has become practically extinct over wide reaches of the rivers, especially below the metropolitan area of Pittsburgh. Where even only twenty years ago representatives of various species of mussel-shells were still comparatively abundant they have now ceased to exist. The shores of Neville Island below the city in the last decade of the nineteenth century possessed a very extensive molluscan population, which is now dead and gone, as completely extinct as the Indians, who once lived there, and derived part of their sustenance from the beds of shell-fish, which were found along the river. Fortunately the Carnegie Museum possesses several collections made many years ago in the region, and the indefatigable industry of Dr. Ortmann has supplemented these by great quantities of specimens, which he has himself gathered, or secured through the coöperation of others whom he has filled with his own enthusiasm. He thus possessed as the basis of his labors material such as exists in no other museum in the world, and his work will always remain a monument not only to his learning but to his scientific energy. Alas! it is in the main a record of that which is past. The rich fauna which once filled the streams is practically extinct, except as represented here and there by remnants. The student of future years will find the only memorial of this great assemblage of species in the cabinets of the Carnegie Museum.

FROM South America during the past ten months we have received

important collections of birds made among the Andes of Colombia, and on the lower waters of the Amazons. A large collection from Bolivia has also been received. The collection of birds in the Carnegie Museum is now quite the largest in the state of Pennsylvania, and in exceptionally fine condition. Our assemblage of the species found in the Neotropical Region is growing apace, and we hope before many years have passed to be able to claim the possession in our cabinets of representatives of all the species known to exist in the Western Hemisphere. We shall be satisfied with nothing less.

THE library of the Museum has recently been enriched by a number of important and classic works upon ornithology, which heretofore have been lacking, but which were needed for reference. Our assemblage of works upon ornithology, including those in the private library of the Director, deposited in the Museum, is rapidly becoming one of the most extensive upon the continent.

SINCE the last issue of the ANNALS was sent to the press the Museum has been visited by many distinguished men of science and men of affairs. Our most notable recent visitors were the King of the Belgians, his Queen, and their son, the Crown Prince, who were accompanied by their party, among these His Excellency, Baron E. De Cartier, the Belgian Ambassador to the United States, and His Excellency, Mr. Brand Whitlock, the American Ambassador to Belgium. Their visit occurred on Thursday, October 23, 1919.

It was the privilege of the Director of the Museum, acting in his capacity as Chairman of the Standing Committee on Honorary Degrees of the University of Pittsburgh, to present His Majesty for the Honorary Degree of Doctor of Laws, which was conferred upon him by the Chancellor at 10 a.m. in the Soldiers and Sailors Memorial Hall, in the presence of an immense audience. After this ceremony had been completed, the party repaired to the main building of the Carnegie Institute, where they were welcomed by the President and Members of the Board of Trustees. The Director had the pleasure of giving them a necessarily somewhat hasty view of some of the treasures of the Museum, after which they repaired to his office, where they were presented to a number of persons, whom they had

expressed a desire to meet because of the services they had rendered to the cause of suffering Belgium. Several of these friends received at the hands of the King and the Queen souvenirs of their visit in the form of decorations. It may be proper to mention that the office of the Director is at least for the time being the Belgian Consulate in Pittsburgh, the Director for some time past having consented as an act of friendship to attend to Belgian affairs in the western half of the Commonwealth of Pennsylvania.

I. SALTATORIAL ORTHOPTERA FROM SOUTH AMERICA AND THE ISLE OF PINES.

By Lawrence Bruner.

Introductory.

The following pages relate to a rather considerable number of saltatorial Orthoptera collected for the Carnegie Museum in Argentina and Bolivia by Mr. José Steinbach, and in French Guiana and the State of Pará, Brazil, by Mr. S. M. Klages. A few species from the Isle of Pines, collected by the late Mr. G. A. Link, Sr., and his associates, are included in the report. The latter were obtained some years ago, but the collections made by Mr. Steinbach, and those made by Mr. Klages, have come into the possession of the Museum in quite recent years. The writer in the spring of 1919 was prepared to submit a report upon those parts of this assemblage of insects which had at that time come into his hands, but the receipt of later collections made in the remote interior of French Guiana and about Pará by Mr. Klages, seemed to make it preferable to withhold this report, until the more recently acquired material could be studied and the results of such investigation incorporated with what had already been written. This was a fortunate decision, as the material alluded to, which was received by the Museum in the summer of 1919, proved to be rather interesting, and to contain a number of apparently undescribed forms. Every sending of insects from the little-visited parts of tropical America reveals the fact that our knowledge of the fauna is not yet complete. In the papers upon the Orthoptera of the American tropics, which the writer has presented in the pages of the Annals of the Carnegie Museum, including the present report, there have been described over two hundred and sixty (264) species new to science. The types of these species are of course all preserved in the Museum in Pittsburgh, where they may be consulted by future students of the order.

In this, as in former papers by the writer issued by the Carnegie Museum, synoptic keys of the species in a given genus have been

frequently given, and occasionally keys to the genera themselves have been supplied.

Order SALTATORIA.

Part I.—Suborder *LOCUSTOIDEA*.

LOCUSTS OR SHORT-HORNED GRASSHOPPERS.

The insects, which are included in this suborder of the Saltatorial Orthoptera, are very numerous and widely scattered over the surface of the earth, wherever there is sufficient vegetation to afford them sustenance and where they may find security against some of their host of enemies. Of course, as might be expected, the species and individuals are most abundant in warmer and more humid regions. Nevertheless comparatively numerous representatives of the group are to be met with in hot, arid regions, as well as in cooler countries towards the poles.

In the introductions to the sections dealing with families, contained in former papers on these insects, I have written somewhat extensively upon their life-histories, food-habits, and distribution. I will not here repeat what already has been said upon these subjects.

In the present paper over thirty supposedly new forms are characterized. We may readily infer, that, when the entire South American continent shall have been thoroughly explored, and its orthopterous fauna collected and studied, there will be still many more species of these insects discovered and made known to science.

Family TETRIGIDÆ (Acrydiidæ).

The present collection contains a number of "grouse-locusts" several of which appear to be undescribed. Undoubtedly considerable additions remain to be made to our present knowledge of these interesting little insects, so far as South American forms are concerned. In 1910 the present author published in the ANNALS (VII, pp. 89–143) a special paper on these insects based on a quite extensive collection belonging to the Carnegie Museum. While that paper was not intended to be a regular synopsis or monograph of the group under consideration so far as South American forms are concerned, it was nevertheless a rather full review. Since that time both the writer and several others have added to that which was known about them for the region.

Without here attempting to give additional notes on their haunts, distribution, habits, etc., I may refer the student of the group to my former paper for hints as to these matters.

Genus COTYS Bolivar.

Cotys BOLIVAR, Ann. Soc. Ent. Belg., xxxi, pp. 186, 194, 247 (1887); HANCOCK, Gen. Ins., Fasc. 48, Orth., Acrid. Tetr., pp. 30, 35 (1906).

The genus *Cotys* belongs solely to the American hemisphere and contains but a single representative.

1. **Cotys antennatus** Bolivar.

Cotys antennatus BOLIVAR, Ann. Soc. Ent. Belg., xxxi, pp. 186, 247, No. 1 (1887); HANCOCK, *l. c.*, p. 35, No. 1, pl. 4, fig. 34 (1906).

This species is represented by two specimens, male and female. They come from the Rio Japacani in eastern Bolivia, where they were taken by J. Steinbach in February, 1915. C. M. Acc. No. 5573.

Genus AMORPHOPUS Serville.

Amorphopus SERVILLE, Ins. Orth., p. 756 (1839); BOLIVAR, Ann. Soc. Ent. Belg., xxxi, pp. 186, 194, 250 (1887); HANCOCK, Gen. Ins., Fasc. 48, Orth., Acrid. Tetr., pp. 31, 36 (1906).

The genus *Amorphopus* is made up of several species of tropical American grouse-locusts, which rather closely resemble each other. They are to be met with either on rocks in or at the margins of streams, or on the trunks of trees and on rocks in damp, shady situations, where mosses and lichens abound.

2. **Amorphopus notabilis** Serville.

Amorphopus notabilis SERVILLE, Ins. Orth., p. 757, No. 1, pl. 13, fig. 5 (1839); BOLIVAR, *l. c.*, pp. 186, 250, 252, No. 5, pl. 5, figs. 20, 20*a*–*b* (1887); HANCOCK, *l. c.*, p. 37, No. 1, pl. 4, fig. 38 (1906); BRUNER, Ann. Carnegie Mus., VII, pp. 90, 97 (1910).

Only a single female specimen of this species is at hand. It comes from eastern Bolivia, where it was captured in February by J. Steinbach. C. M. Acc. No. 5573.

Genus EOMORPHOPUS Hancock.

Eomorphopus HANCOCK, Gen. Ins., Fasc. 48, Orth., Acrid. Tetr., pp. 31, 37 (1906); BRUNER, Ann. Carnegie Mus., VII, pp. 90, 98 (1910).

The representatives of this genus belong to the South American tropics. They may be separated from those of the preceding genus

by their less flattened or depressed bodies and the non-clypeate anterior femora.

3. **Eomorphopus granulatus** Hancock.

Eomorphopus granulatus HANCOCK, *l. c.*, p. 38, no. 2, pl. 4, figs. 35, 35*a* (1906); BRUNER, *l. c.*, p. 98 (1910).

The following listed material is at hand: 1 ♂, 4 ♀♀, Benevides, Pará, Brazil, October 1918 (S. M. Klages), Acc. No. 6174; 1 ♀, Oucatopi Island, June, 1918, Acc. No. 6178; 1 ♀, Cayenne, Acc. No. 5897; 1 ♀, Mana River, French Guiana, May, 1917, Acc. No. 6008.

Genus PLATYTETTIX Hancock.

Platytettix HANCOCK, Ent. News, XVII, 1906, 88; Gen. Ins., Fasc. 48, Orth. Acrid. Tetr., 1906, 39; BRUNER, Ann. Car. Mus., VII, 1911, 99.

4. **Platytettix arcuatus** sp. nov.

Having the same general appearance as the remainder of the representatives of the genus *Platytettix*, but a little smaller than either *gibbinotus* or *uniformis*, which were characterized in a former number of the ANNALS (Vol. VII, pp. 99–100, 1910). In the synoptic table for the separation of the known species of the genus the present form falls between the two here referred to. If we include this species, the key should be modified as follows:

KEY TO THE SPECIES OF PLATYTETTIX.

A. Pronotum strongly reticulate and gibbous.
  b. Larger (8 to 9 mm. in length).
    c. Apex of the anterior edge of the posterior lateral lobes of the pronotum greatly produced and acuminate. . . . . *reticulatus* Hancock.
    cc. Apex of the posterior lateral lobes but little produced. *gibbinotus* Bruner.
  bb. Smaller (6.5–7 mm. in length). The posterior lateral lobes but little produced, nevertheless still angulate. . . . . *arcuatus* sp. nov.
AA. Pronotum comparatively smooth. The posterior angles of the lateral lobes roundly angulate (7 mm.). . . . . *uniformis* Bruner.

As seen by an examination of the above key, *arcuatus* has the pronotum moderately gibbous, but is smaller than the others. The pronotum is rather greatly elevated on its anterior half and evenly arcuate and ascending from the front edge to the point of its greatest

height, where it suddenly and a little obliquely drops to a level with the anterior edge. The lower apical half of the disc of the pronotum is nearly flat, and provided with several oblique carinæ, which extend from the well-marked nearly equal and smooth median carina to the lateral edges. The anterior margin at middle straight, the apex is sharply acuminate and extends little, if any, beyond the apex of the valves of the ovipositor. The gibbosities are chiefly confined to the lateral lobes anteriorly and below the lateral carinæ. The lobes of the carinæ of the anterior and middle femora are less well-defined than in *reticulatus*, especially is this true with reference to the superior ones. Front, frontal costa, and vertex about normal for the genus.

General color dark brunneo-fuscous, varied with pale testaceous and dull cinereous. Anterior and middle tibiæ fasciate, the apical portion of the tarsi infuscated. Hind femora with their apical half and the tibiæ largely testaceous, marmorate with browns. Apical depressed portion of the disc of the pronotum pale testaceous Apical four or five joints of the antennæ pallid, the middle ones infuscated, while those at the base are more or less varied with testaceous. Dorsal carina of the pronotum alternately pallid and fuscous.

Length of body, ♀, 6.5 mm.; of pronotum, 6 mm.; of hind femora, 4 mm.

Habitat: The only specimen at hand, the type, bears the label "Pied Saut, Oyapok River, French Guiana, S. M. Klages, C. M. Acc. No. 6111." It was taken in November, 1917.

Genus CRIMISUS Bolivar.

Crimisus BOLIVAR, Ann. Soc. Ent. Belg., xxxi, p. 246 (1887); HANCOCK, Gen. Ins., Fasc. 48, Orth. Acrid. Tetr., pp. 31, 40 (1906); BRUNER, Ann. Carnegie Mus., VII, pp. 91, 103 (1910).

The only representative of the genus at hand is a single specimen of the following species.

5. **Crimisus patruus** Bolivar.

Crimisus patruus BOLIVAR, *l. c.*, p. 247 (1887); HANCOCK, *l. c.*, p. 40 (1906); BRUNER, *l. c.*, pp. 103, 104 (1910).

1 ♂, Rio Japacani, eastern Bolivia, Feb., 1915, J. Steinbach, collector. C. M. Acc. No. 5573

Genus OTUMBA Morse.

Otumba MORSE, Biol. Cent.-Amer., Orth., II, pp. 5, 7 (1900); HANCOCK, Tett. N. Amer., pp. 34, 50 (1902); IB., Gen. Ins., Fasc. 48, Orth. Acrid. Tetr., pp. 32, 43 (1906); BRUNER, Ann. Carnegie Mus., VII, pp. 91, 110 (1910).

A strictly tropical American genus containing several rather common species.

6. **Otumba lobata** Hancock.

Otumba lobata HANCOCK, *l. c.*, 2nd reference, pp. 44, 45, no. 4 (1906); BRUNER, *l. c.*, pp. 110, 111 (1910).

This grouse-locust is represented in the material now being reported upon by the following specimens: 1 ♂, 2 ♀♀, Mana River, May, 1917, C. M. Acc. No. 6008; 1 ♀, Pied Saut, Oyapok River, French Guiana, Dec., 1917, S. M. Klages, collector, C. M. Acc. No. 6111.

Genus ALLOTETTIX Hancock.

Allotettix HANCOCK, Ent. News, x, p. 276 (1899); IB., Tettig. N. Amer., pp. 126, 127 (1902); IB., Gen. Ins., Fasc. 48, Orth. Acrid. Tetr., pp. 48 (1906); BRUNER, Ann. Carnegie Mus., VII, p. 114 (1910).

Allotettix is another of our tropical American genera of grouse-locusts. Its representatives are all extremely slender insects with greatly lengthened wings and pronotal shield. Eight species have been recognized and characterized. At least three of these are found among the material now being examined.

7. **Allotettix chipmani** Bruner.

Allotettix chipmani BRUNER, Journ. N. Y. Ent. Soc., XIV, p. 146 (1906); IB., Ann. Carnegie Mus., VII, pp. 115, 116 (1910); HANCOCK, Gen. Ins., Fasc. 48, Orth. Acrid. Tetr., p. 48 (1906).

There are quite a number of specimens of both sexes of this insect before me as I write. They come chiefly from the Mana River in French Guiana and were taken during the months of May and June, 1917. C. M. Acc. No. 6008. Three other specimens are also at hand, which are referred to this species, one male and two females, from the Oucatopi Island, where they were taken in June, 1918, by S. M. Klages. C. M. Acc. No. 6178.

8. **Allotettix peruvianus** (Bolivar).

Paratettix peruvianus BOLIVAR, Ann. Soc. Ent. Belg., XXXI, p. 272 (1887).

Allotettix peruvianus HANCOCK, Gen. Ins., Fasc. 48, Orth. Acrid. Tetr., p. 48, fig. 18 (1906); BRUNER, Ann. Carnegie Mus., VII, pp. 115, 116 (1910).

Specimens of both sexes of a rather slender rugose-granulose grouse-locust coming from the Province del Sara, Bolivia, are referred to Bolivar's *Paratettix peruvianus*. They were taken at the same time and locality as the following insect, which has been determined as *Allotettix chapadensis* described by me (see ANNALS CAR. MUS., VII, p. 117). The present lot was taken by J. Steinbach. C. M. Acc. No. 5573.

9. **Allotettix chapadensis** Bruner.

Allotettix chapadensis BRUNER, Ann. Carnegie Mus., VII, pp. 115, 117 (1910).

All the specimens in the present collection, which are referred to this species, come from the Province del Sara, Bolivia. They were taken by J. Steinbach in October and December, and were found at an elevation of about 350 meters above sea-level. Both sexes are represented. C. M. Acc. No. 5058.

10. **Allotettix** sp.?

In addition to the three species of *Allotettix* recorded above there is a single male of what seems to be a fourth species at hand. It was taken at Las Juntas, in the Department of Santa Cruz, Bolivia, at an elevation of 250 meters above sea-level, in December, 1913, by J. Steinbach. C. M. Acc. No. 5060.

It is not as rugulose as is usually the case in representatives of the genus, but is instead remarkably coarsely granulose, and has the median carina of the pronotum quite prominent and of nearly equal height throughout. The vertex is also a little more advanced in front than is usual in representatives of this genus. I refrain, in view of the paucity of the material, from giving it a specific name.

Genus RYTINATETTIX Hancock.

Rytinatettix HANCOCK, Trans. Ent. Soc. Lond., 1908, p. 418 (1908); REHN, Trans. Amer. Ent. Soc., XLIII, p. 343.

As shown by Mr. Jas. A. G. Rehn (*l. c.*) Hancock created the genus *Rytinatettix* for the reception of the *Prototettix fossulatus* of Bolivar and the *Tetrix lobulata* of Stål, as well as the *Paratettix borellii* of Giglio-Tos.

11. **Rytinatettix fossulatus** Bolivar.

Prototettix fossulatus BOLIVAR, Ann. Soc. Ent. Belg., xxxi, pp. 255, 256 (1887); BRUNER, Ann. Carnegie Mus., VII, pp. 92, 122 (1910); REHN, Trans. Am. Ent. Soc., XLIII, p. 342 (1917).

Paratettix borellii GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torin., XII, no. 302 (1897), pp. 28–29; BRUNER, Locusts of Argentina, 1900, p. 16; IB., Ann. Carnegie Mus., VII, p. 119 (1910); HANCOCK, Gen. Ins., Fasc. 48, Orth. Tetr., p. 56 (1906); REHN, Trans. Amer. Ent. Soc., XLIII, p. 343 (1910), footnote.

A single female specimen of a small robust grouse-locust, which was at first determined by me as *Paratettix borellii* of Giglio-Tos, seems to belong in the present genus as limited and defined by Hancock. Our specimen agrees fairly well with the descriptions of both *lobulatus* Stål and *fossulatus* Bolivar. But when compared with specimens of *Paratettix borellii* in my possession, coming from Argentina, I am inclined to choose Rehn's diagnosis as more nearly correct. The specimen is from the Province del Sara, Bolivia, where it was taken by J. Steinbach during the period from March to April, 1913, at a locality about 350 meters above sea-level. C. M. Acc. No. 5058.

12. **Rytinatettix affinis** sp. nov. (?)

A second specimen, a male, also apparently belonging to this genus, is at hand. It comes from the Rio Bermejo in the Province of Salta, Argentina, where it was taken at an elevation of 400 meters above sea-level. In general appearance it is much smoother and has longer wings and pronotum than the preceding insect. It may be called *Rytinatettix affinis*. It is dull ferruginous, or inclining to wood-brown, and faintly variegated with fuscous. The median carina of the pronotum is less prominent and only moderately undulate. Its measurements are as follows: Length of body, ♂, 6.5 mm.; of pronotum, 9 mm.; of posterior femora, 5 mm.; the wings extend 1 mm. beyond the apex of the pronotum. Collected by J. Steinbach, May, 1914.

Genus TETTIGIDEA Scudder.

Tettigidea SCUDDER, Bost. Journ. Nat. Hist., VIII (1862), p. 476; BOLIVAR, Ann. Soc. Ent. Belg., XXXI (1887), p. 299; HANCOCK, Gen. Ins., Fasc. 48, Orth. Tetr., p. 67 (1906); BRUNER, Ann. Carnegie Mus., VII, p. 123 (1910).

13. **Tettigidea glabrata** sp. nov.

A moderately large, but not excessively robust insect, having a nearly uniform dark fusco-brunneous color, the entire surface of which is glabrous, or, I might say, appearing to have been freshly varnished. Viewed laterally, the insect has a rather fusiform wedge shape, *i.e.*, the sides and edges of the wedge are somewhat arcuate or

gently bowed outward at middle. Apex of pronotum only reaching the tip of the hind femora. Wings not apparent or visible. Notwithstanding the glabrous appearance of this insect, it nevertheless has the surface of both the dorsum and lateral lobes of the pronotum very coarsely rugulose or wrinkled. On the disc two of these rugæ assume the form of supplemental, but rather irregular, longitudinal carinæ on each side of the middle, accompanied by many independent short and transverse carinæ, some of which unite with the longitudinal ones. Anterior margin of the pronotum both angulated and spined, the latter extending forward over the occiput to the middle of the eyes. Latter not prominent, sub-triangular in form, the front edge longest, the ventro- and dorso-posterior sides rounded and of about equal length. Occiput and summit of head somewhat, but not greatly, raised above the upper portion of the eyes, provided with a deep wide sulcus, which receives the pronotal spine from behind and the upper and backwardly directed portion of the frontal costa from the front. Frontal costa rather narrow and very narrowly sulcate; viewed from the side nearly straight and not greatly produced in front of the eyes. Antennæ missing. Anterior and middle legs slender; hind femora fairly robust, but elongate, provided with the usual rugæ, but these are somewhat irregular, especially on the disc. Hind tibiæ with the lateral edges acute and provided with many regularly arranged, rather acute, small spines. Labial palpi with two apical segments flattened and ivory-white. Under side of body and tibiæ piceous.

Length of body, ♀, 14 mm.; of pronotum, 13 mm.; of hind femora, 8 mm.

Habitat: The only specimen at hand, the type, comes from Oucatopi Island, where it was taken by S. M. Klages in June, 1918. C. M. Acc. No. 6178.

(*Note.*—Could this insect be the *Tetrix purpurascens* of Serville?)

14. **Tettigidea paratecta** Rehn?

Tettigidea paratecta REHN, Proc. Acad. Nat. Sci. Philad., May, 1913, pp. 304–306, figs. 10 and 11 (1913).

A single female specimen of the genus *Tettigidea*, from the Rio Japacani of eastern Bolivia, is referred here for the present at least. It was taken by J. Steinbach in February, 1915. C. M. Acc. No. 5573.

At first glance it seemed to be an immature individual of the following species, but this can hardly be the case, since it lacks the spine

on the anterior middle of the pronotum. It also has a more arcuate and deeper pronotum than the insect with which it has been compared.

15. **Tettigidea steinbachi** sp. nov.

A medium-sized long-winged species. Somewhat robust, but could not be termed incrassate. Smaller than *T. hancocki*, and more finely rugose or even granulose than that species; the supplemental longitudinal carinæ of the disc three in number on each side, reaching a point a little beyond the basal fourth of the hind femora. Pronotum angulate in front, as well as provided with an acute spine, the apex of which reaches a point opposite (♂) the middle of the upper edges of the eyes, or a little in advance of this (♀). Frontal costa rather prominent and deeply sulcate, the sides or carinæ not very heavy, and evenly converging upward. The apex a little advanced in front of the eyes and quite deeply and broadly sulcate, the upper extremity of the frontal costa almost reaching (♀), or not quite (♂) the apex of the anteriorly projecting spine of the pronotum. Posterior extremity of the latter reaching the tips of the hind femora, the wings somewhat longer. Hind femora rather robust at their base. Tibial spines quite large and regularly placed.

General color pale fuscous, the dorsum or disc of the male pronotum a little paler, and with the femora, the abdomen, and sides of the pronotum and head, varied with dull black or dark fuscous. Tegmina unicolorous or very faintly paler apically.

Length of body, ♂, 10 mm., ♀, 11 mm.; of pronotum, ♂, 10.5 mm., ♀, 12 mm.; of hind femora, ♂, 6 mm., ♀, 7.5 mm.

Habitat: Province del Sara, Bolivia, 1 ♂, 1 ♀, the types. Collected by J. Steinbach at an elevation of 350 meters above sea-level. The male was taken in February, 1913, and the female in October, 1912.

16. **Tettigidea costalis** Bruner.

Tettigidea costalis BRUNER, Ann. Carnegie Mus., VII, p. 133 (1910).

There is a single male specimen of this species before me. It comes from Las Juntas, Department of Santa Cruz, Bolivia, where it was taken in December, 1913, by J. Steinbach. It is much more robust than the same sex of *T. lateralis* of North America and has its hind femora prominently marked by a large median testaceous patch.

17. **Tettigidea multicostata** Bolivar.

Tettigidea multicostata BOLIVAR, Ann. Soc. Ent. Belg., XXXI, p. 299 (1887); BRUNER, Locusts of Argentina, 1900, p. 17; IB., Proc. U. S. Nat. Mus., XXX, p. 616 (1906); IB., Ann. Carnegie Mus., VII, p. 136 (1910); HANCOCK, Genera Ins., Fasc. 48, Orth. Tetr., p. 68 (1906).

A single female nymph belonging in this genus is referred here. It bears the label "Rio Bermejo, Prov. of Salta, Argentina, 400 m." It was collected by J. Steinbach in May, 1914.

Genus SCARIA Bolivar.

Scaria BOLIVAR, Ann. Soc. Ent. Belg., XXXI, p. 301 (1887); HANCOCK, Genera Ins., Fasc. 48, Orth. Tetr., p. 69 (1906); BRUNER, Ann. Carnegie Mus., VII, p. 140 (1910).

18. **Scaria hamata** (De Geer).

Acrydium hamatum DE GEER, Mém. Ins., III, p. 503 (1773), no. 22, pl. 42, fig. 13.
Tettix hamatus STÅL, Recens. Orthopt., I, p. 146 (1873).
Scaria hamata BOLIVAR, Ann. Soc. Ent. Belg., XXXI, p. 301 (1887); HANCOCK, Gen. Ins., Orth., Acrid. Tetr., Fasc. 48, p. 69 (1906); BRUNER, Ann. Carnegie Mus., VII, p. 140 (1910).

A single male and three females of the genus *Scaria* are referred to this species. They come from the Mana River of French Guiana, where they were taken in May, 1917. C. M. Acc. No. 6008.

19. **Scaria producta** Hancock.

Scaria producta HANCOCK, Gen. Ins., Fasc. 48, Orth. Acrid., Tetr., p. 70 (1906); BRUNER, Ann. Carnegie Mus., VII, p. 140 (1910).

A female of this species collected by J. Steinbach on the Rio Japacani in eastern Bolivia, in February, 1915. C. M. Acc. No. 5573.

20. **Scaria boliviana** sp. nov.

Rather closely related to the *Acrydium hamatum* of De Geer, as shown by the flavo-maculate tegmina, but smaller, and lacking the depressed areas on the disc of the pronotum back of the shoulders. In color the present species is testaceo-fuscous varied with black on the sides, legs, and median carina of the pronotum. Moderately robust, finely granulose, the hind femora a little robust, not as long in proportion as in the species *producta*, a specimen of which latter is before me for comparison.

Length of body, ♀, 11.5 mm.; of pronotum, 13 mm.; of hind femora, 7 mm.

Habitat: The type, a female, comes from Las Juntas, Department of Santa Cruz, Bolivia, where it was taken in December, 1913, by J. Steinbach at an elevation of 250 meters above sea-level. A second specimen, also a female, bears the label "Quatro Ojos, Dept. Sta. Cruz, Bolivia, 300 m." It was likewise taken by Steinbach, but in November.

Genus BATRACHIDEA Serville.

Batrachidea SERVILLE, Hist. Nat. Ins. Orth., p. 764 (1839); BOLIVAR, Ann. Soc. Ent. Belg., XXXI, p. 126 (1887); BRUNER, Ann. Carnegie Mus., VII, p. 141 (1910). Not the genus *Batrachidea* as meant by Scudder, Thomas, or Saussure.

21. **Batrachidea mucronata** (Serville)?

Tetrix (*Batrachidea*) *mucronata* SERVILLE, Hist. Ins. Orth., p. 764 (1839).

Tetrix mucronata SERVILLE, Encycl. Méth., X, p. 600 (1839).

Acridium (*Tetrix*) *mucronatum* DE HAAN, Bijdrag. tot de Kennis Orthopt., p. 166 (1842).

Batrachidea mucronata BOLIVAR, Ann. Soc. Ent. Belg., XXXI, p. 300 (1887); HANCOCK, Genera Ins., Fasc. 48, Orth. Acrid., Tetr., p. 70 (1906); BRUNER, Ann. Carnegie Mus., VII, p. 141 (1910).

Two females from the Rio Japacani, eastern Bolivia, belong here. They were collected by J. Steinbach. C. M. Acc. No. 5573.

A single female specimen from Quatro Ojos, Department of Santa Cruz, Bolivia, taken by J. Steinbach in November, 1913, is also referred here, but with some doubt. Like the four specimens referred to in a former paper (ANNALS C. M., VII, p. 141) this insect has the frontal costa *widely*, rather than *narrowly* furcillate. All may represent a distinct species.

22. **Batrachidea notata** Hancock.

Batrachidea notata HANCOCK, in BRUNER, Proc. U. S. Nat. Mus., XXX, pp. 616–617 (1906); HANCOCK, Genera Ins., Fasc. 48, Orth. Acrid., Tetr., p. 70 (1906); BRUNER, Ann. Carnegie Mus., VII, p. 142 (1910).

A female of an insect, which appears to belong here, comes from Las Juntas, Department of Santa Cruz, Bolivia. It was taken by J. Steinbach at an altitude of 250 meters above sea-level in December, 1913. It has the pronotum a trifle shorter than to the apex of the hind femora, while the wings are still somewhat shorter.

Genus PAUROTARSUS Hancock.

Paurotarsus HANCOCK, Psyche, IX, p. 42 (1900); IB., Gen. Ins., Fasc. 48, Orth. Acrid., Tetr., pp. 70–71 (1906); BRUNER, Ann. Carnegie Mus., VII, p. 142 (1910).

The representatives of the genus *Paurotarsus* are rather large insects for the group of locusts to which they belong, and bear a general resemblance to some of the species of *Tettigidea*. Three species have been recognized thus far. These may be separated by the annexed synoptic key:

A. Carinæ of the frontal costa very heavy, almost obliterating the otherwise moderately wide sulcus (Brazil).

b. Frontal costa strongly protuberant, the anterior margin of the frontal disc decidedly angulate, median carina depressed between the humeri; hind femora more elongate and slender; the caudal metatarsal joint less than a third longer than the distal joint (Brazil). . . *insolitus* Rehn.

bb. Frontal costa only moderately protuberant, the anterior margin of the pronotum not decidedly angulate, the median carina between the humeri not noticeably depressed; hind femora more robust and less elongate; the caudal metatarsal joint fully twice as long as the distal joint. . . . . *amazonus* Hancock.

AA. Carinæ of the frontal costa only moderately heavy, leaving the sulcus fairly wide (Island of Trinidad). . . . . *rugosus* Bruner.

23. **Paurotarsus amazonus** Hancock.

Paurotarsus amazonus HANCOCK, *l. c.*

2 ♀♀, Mana River, French Guiana, May, 1917, C. M. Acc. No. 6008.

Family EUMASTACIDÆ.

Genus EUMASTAX Burr.

Eumastax BURR, Essai sur les Eumastacides, pp. 43, 45 (1899); IB., Gen. Ins., Fasc. 15, Orth. Eumastac., p. 15 (1903).

24. **Eumastax vittata** Burr.

Eumastax vittata BURR, Essai sur les Eumastacicides, pp. 44, 46 (1899); KIRBY, Syn. Cat. Orthopt., III, p. 76 (1910).

A single male specimen of this species is at hand. It comes from Quatro Ojos, Department of Santa Cruz, Bolivia, where it was taken in November, 1913, at an elevation of 300 meters above sea-level by J. Steinbach. There are also two males and two females in the collections, which come from Buena Vista, eastern Bolivia, and were taken in February, 1915, by J. Steinbach. C. M. Acc. No. 5573.

25. **Eumastax tenuis** (Perty)?

Mastax tenuis PERTY, Delect. Anim. Brasil, p. 123, tab. XXIV, fig. 3 (1830).

Mastax virescens WESTWOOD, Arc. Ent., I, p. 100 (1841).

Mastax minuta BOLIVAR, An. Soc. Españ. Hist. Nat., X, p. 481 (1881).

Eumastax tenuis BURR, Essai sur les Eumastacides, pp. 44, 45 (1899); IB., Gen. Ins., Fasc. 15, Orthop. Eumastac, p. 16 (1903).

Two females belonging to the genus *Eumastax* are referred to this species, even though they are a little small, as compared with the measurements given for it. They are from Buena Vista, eastern Bolivia, where they were collected by J. Steinbach, C. M. Acc. No. 5573.

26. **Eumastax militaris** (Gerstæcker)?

Mastax militaris GERSTÆCKER, Mitth. Neu-Vorpomm. u. Rügen, XIX, and XX, p. 84 (1888); KARSCH, Ent. Nachr., XV, p. 36 p. 36 (1889).

Eumastax militaris BURR, Essai sur les Eumastacides, pp. 44, 54 (1899); IB., Gen. Ins., Fasc. 15, Orth. Eumast., p. 16 (1903).

Three female specimens taken in the month of May, 1917, bear the label "Mana River, Fr. Guiana." They were evidently collected by S. M. Klages, and belong to C. M. Acc. No. 6008. A fourth specimen, also a female, is from the Upper Rocana, N. Pará, Brazil. It was taken by the same collector in July, 1918, C. M. Acc. No. 6175.

These specimens are doubtfully referred to *militaris*, since they come from a region rather widely removed from the habitat given for the species.

Genus PARAMASTAX Burr.

Paramastax BURR, An. Soc. Españ., Hist. Nat., XXVIII, pp. 90, 94, 268 (1899); IB., Gen. Ins., Fasc. 15, Orth. Eumastac., pp. 15, 16 (1903); BRUNER, Biol. Cent. Amer., Orth., II, pp. 20, 23 (1901); SAUSSURE, Rev. Suisse Zoöl., XI, p. 91 (1903); KIRBY, Syn. Cat. Orth., III, p. 77 (1910).

This is one of the larger genera of the family the species of which are wholly confined to tropical America and chiefly to South America. At least nine species have thus far been recognized, and a tenth is now added. They are all more or less gaudily colored, and may be separated by the accompanying synoptical table based on the males. It is a modification of the keys given by Burr and Saussure:

SYNOPSIS OF THE SPECIES OF PARAMASTAX.

A. Cerci of males forked.

b. Anterior and middle legs black. Wings cinnamon-brown.. *gaudens* Burr.

bb. Anterior and middle legs rufous.

c. Wings æneous or brassy, shining.

d. Hind femora rufous towards the apex..... *vicina* Burr.

dd. Hind femora with their apex infuscate, not rufous.

magna Giglio-Tos.

cc. Wings hyaline-orange or cupreous. Anterior and middle legs rufous. . . . . *brevipennis* Burr.

AA. Cerci of the males simple, not forked.

b. Wings white. . . . . *nigra* Scudder.

bb. Wings hyaline orange. Thorax and abdomen in part striped with yellow on the sides. Scutellum of the face flavomaculate.

c. Cheeks immaculate.

d. Eighth segment of the abdomen with its margin above two-spined. . . . . *læta* Gerst.

dd. Eighth segment of the abdomen above emarginate, in the middle sinuose. . . . . *personata* Burr.

cc. Cheeks and between the eyes ornamented with yellow.

d. Front and cheeks with a transverse yellow band. Antennæ black. . . . . *tæniata* Sauss.

dd. Front and cheeks largely yellow. Base of antennæ yellow.

e. Larger (♂, 29 mm.; ♀, 29 mm.). Antennæ largely rufous or vinaceous red, only at extreme apex infuscated. Front with its lower margin and a narrow arcuate transverse band below the antennæ black. *pictifrons* sp. nov.

ee. Smaller (♂, 15 mm.). Antennæ, except basal segments, black. Front entirely yellow. . . . . *facialis* Sauss.

27. **Paramastax pictifrons** sp. nov.

Related to the species *P. tæniata* and *P. facialis* of Saussure, but considerably larger than either. A beautiful insect, conspicuously ornamented with yellow and white on the head and sides of the meso- and metathorax.

General color of the male olivaceo-testaceous; the anterior and middle legs rufous; carinæ of the hind femora and spines of the hind tibiæ black; head on the occiput, hind and lower margins of the cheeks and lower edge of the front, together with the base of the clypeus, black, remainder yellow; antennæ with two basal joints yellow, remainder reddish, becoming infuscated apically. Sides of the abdomen and thorax back of the pronotum conspicuously banded with creamy white, this band placed between upper and lower infuscated borders, becoming gradually narrower toward its posterior end. Tegmina fuscous, their veins testaceous; wings slightly hyaline with a cupreous tinge basally. Apex of the hind femora rather lengthily infuscated. The general color of the female is a dark wood-brown with the sides of the meso- and metathorax and three basal abdominal segments conspicuously and broadly ornamented with a

longitudinal pallid stripe, bordered above and below by black, which gradually fades away into the general hue of the body. Face and cheeks paler than the remainder of the head and the body of the insect, but not yellow, as in the male. Antennæ and anterior and middle legs pale vinaceous red. Cerci of the male somewhat spatulate apically, rather strongly curved inward and downward; the hind margin of the eighth abdominal segment above widely and roundly emarginate, the sides of the emargination provided with a short coarse tooth.

Length of body, ♂, 20 mm., ♀, 29 mm.; of pronotum, ♀, 2.8 mm., ♀, 3.1 mm.; of tegmina, ♂, 14 mm., ♀, 15 mm.; of hind femora, ♂, 15 mm., ♀, 18 mm.

Habitat: The type, a male, comes from Las Juntas, Department of Santa Cruz, Bolivia, where it was taken in December, 1913. Two additional males and three females from the same locality are also at hand. They were all taken by J. Steinbach, and belong to C. M. Acc. No. 5060. There are also five males and two females before me from Buena Vista, and three males from Rio Japacani, eastern Bolivia. These also were collected by Steinbach, C. M. Acc. No. 5573.

28. **Paramastax nigra** Scudder.

Mastax nigra SCUDDER, Proc. Bost. Soc. Nat. Hist., XVII, p. 266 (1875).

Eumastax nigra BURR, Essai sur les Eumastacides, p. 55 (1899); IB., Gen. Ins., Fasc. 15, Orth. Eumast., p. 16 (1903).

Three males of a species belonging to *Paramastax* are referred to Scudder's *nigra*. They come from the Rio Japacani in eastern Bolivia, where they were collected in February, 1915. C. M. Acc. No. 5573.

These specimens vary somewhat from Scudder's description, but possibly only owing to the condition of preservation, etc.

Genus MASYNTES Karsch.

Masyntes KARSCH, Ent. Nachr., XV, pp. 26, 31 (1889); BURR, Soc. Españ., Hist. Nat., XXVIII, pp. 90, 95, 273 (1899); SAUSSURE, Rev. Suisse Zoöl., XI, p. 99 (1903); BRUNER, Ann. Carnegie Mus., VIII, p. 6 (1910).

29. **Masyntes borellii** Giglio-Tos.

Masyntes borellii GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XII, No. 302, p. 17 (1898); BURR, An. Soc. Españ., Hist. Nat., XXVIII, pp. 90, 274, 275 (1899); REHN, Proc. Acad. Nat. Sci. Philad., LIV, p. 67 (1905); KIRBY, Syn. Cat. Orth., III, p. 79 (1916).

Masyntes mutilata GIGLIO-TOS (*nec* SERVILLE), Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 4 (1894); IB., Zoöl. Jahrb. Syst., VIII, p. 806 (1895).
Masyntes chapadensis BRUNER, Ann. Carnegie Mus., VIII, pp. 6, 8 (1911).

A single male nymph from Province del Sara, Bolivia, is referred to this species. It was collected by J. Steinbach in February, 1913, at an elevation of 350 meters above sea-level.

According to Candido Bolivar the above synonymy should stand (Bol. Real. Soc. Españ., Hist. Nat., XVI, 1916, p. 198). Accordingly I also am temporarily placing in this species two other male specimens, which I had set aside as possibly representing two new species, related to *M. brasiliensis* and *M. tigris*, on account of their abbreviated tegmina and wings. The names suggested were *M. fuscipennis* and *M. steinbachi* respectively, the former being 23 mm. in length with tegmina and wings 7.5–8 mm. long, and the latter 22 mm. in length with tegmina 3.5 mm. long. Both insects have the hind femora twice broadly annulate with testaceous on their apical two-fifths, although much brighter and more strongly defined in *fuscipennis*. Both have fuscous antennæ with the three basal joints pale. The general color of *fuscipennis* above is dark fuscous, without bands of testaceous mottlings. The specimen labelled *steinbachi* is pale brown with longitudinal fuscous bands on the sides of the pronotum. Under side and legs of both insects flavo-testaceous, brightest in *fuscipennis*.

The specimen labelled *fuscipennis* is ticketted "Pr. Chiquitos, Bolivia, 300 M., Steinbach," "April 1909," and "Carn. Mus. Acc. 5229"; the specimen labelled *steinbachi* is ticketted "R. Japacani, E. Bolivia, J. Steinbach," "Feb. 1915," and "Carn. Mus. Acc. 5573."

Family PROSCOPIDÆ.

For remarks on the present family of tropical American locusts please refer to what the writer had to say in a former number of the ANNALS (Vol. VII, pp. 430–431, 1913), where he reported upon a number of forms contained in the Carnegie Museum. The present collection contains but few representatives of this family.

Genus PROSCOPIA Klug.

Proscopia KLUG, Hor. Phys. Berol., p. 17 (1820); ST. FARG. & SERVILLE, Encycl. Meth., Ins., X, p. 211 (1825); SERVILLE, Ann. Sci. Nat., XXII, p. 265 (1831); IB., Ins. Orth., p. 571 (1839); BURMEISTER, Handb. Ent., II, pp. 602, 603 (1838); BRUNNER VON WATTENWYL, Verh. Zoöl.-bot. Ges. Wien., XL, pp. 92, 94 (1890); and others.

The species of this genus seem to be less numerous than are those of some other genera. They may be recognized by the characters given by Brunner von Wattenwyl in his Monograph of the family mentioned above.

30. **Proscopia scabra** Klug.

Proscopia scabra KLUG, *l. c.*, p. 19, no. 2, pl. 3, fig. 2 (1820); BURMEISTER, *l. c.*, p. 604, no. 7 (1839); SERVILLE, *l. c.*, p. 574 (1839); BRUNNER, *l. c.*, pp. 95, 97, no. 5 (1890); REHN, Proc. Acad. Nat. Sci. Philad., 1918, p. 168.

♂. *Proscopia rostrata* KLUG, *l. c.*, p. 24, no. 12, pl. 4, fig. 12 (1820), etc.

Proscopia parallela WALKER, Cat. Derm. Salt. B. M., III, p. 490 (1870).

Taxiarchus paraënsis REHN, Ent. News, XVII, p. 332 (1906).

This species is represented by a male and a female from Cayenne, French Guiana, where they were collected by S. M. Klages in March and April, 1917; C. M. Acc. No. 5873. There is a second male at hand, taken at Benevides, Pará, Brazil, by the same collector in October, 1918; C. M. Acc. No. 6174. This last-mentioned specimen agrees with the one reported upon by Rehn as to color-markings.

Genus TETANORHYNCHUS Brunner.

Tetanorhynchus BRUNNER V. WATTENWYL, Verh. Zoöl.-Bot. Ges. in Wien, XXXIX, pp. 92, 104 (1890); GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XII, no. 302, p. 18 (1897); REHN, Proc. Acad. Nat. Sci. Phil., 1904, p. 677; BRUNER, Ann. Carnegie Mus., VIII, p. 433 (1913).

31. **Tetanorhynchus humilis** Giglio-Tos?

Tetanorchynchus humilis GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XII, no. 302, p. 18 (1897); KIRBY, Syn. Cat. Orthopt., III, p. 86 (1910); BRUNER, Ann. Carnegie Mus., VIII, pp. 435–436 (1913).

Three males, two females, and one nymph from the Province del Sara, Bolivia, are placed here with a question. They do not quite agree with the description given by Giglio-Tos, but approach it closer than anything else. They were taken by J. Steinbach in February, November, and December. A pair were taken *in coitu*. C. M. Acc. No. 5573.

32. **Tetanorhynchus incertus** Brunner?

Tetanorhynchus incertus BRUNNER, Verh. Zoöl.-Bot. Ges. Wien, XL, pp. 105–106 (1890); KIRBY, Syn. Cat. Orthopt., III, p. 86 (1910); BRUNER, Ann. Carnegie Mus., VIII, pp. 437, 439 (1913).

There is a single female specimen at hand, which seems to belong here. It is from Las Juntas, Department of Santa Cruz, Bolivia, 250 meters above sea-level. It was collected by J. Steinbach in December, 1913.

33. **Tetanorhynchus borellii** Giglio-Tos.

Tetanorhynchus borellii GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XII, no. 302, p. 18 (1897); KIRBY, Syn. Cat. Orth., III, p. 86 (1910).

Four males and two females of a third species of this genus appear to be referable to *T. borellii*. They come from the Rio Bermejo, Province of Salta, Argentina. They were collected at an elevation above sea-level of 400 m., in May, 1914, by J. Steinbach. C. M. Acc. No. 5229.

Genus CEPHALOCŒMA Serville.

Cephalocœma SERVILLE, Ins. Orth., p. 577 (1839); BURM, Abh. Ges. Halle, XV, p. 3 (1880); BRUNNER, Verh. Zoöl.-Bot. Ges. Wien, XL, pp. 93, 114 (1890); GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XII, no. 302, pp. 19–20 (1894); BRUNER, Ann. Carnegie Mus., VIII, pp. 439–440 (1913).

For an account of the genus see some remarks by me in the ANNALS for 1913, page 140.

34. **Cephalocœma teretiuscula** Brunner.

Cephalocœma teretiuscula BRUNNER, *l. c.*, pp. 115, 117, no. 6 (1890); GIGLIO-TOS, Boll. Mus. Torino, XII, no. 302, p. 20 (1897).

A male Proscopiid from Buena Vista, eastern Bolivia, is referred here. It was taken by J. Steinbach. C. M. Acc. No. 5573.

Family TRUXALIDÆ.

While the family comprising the truxaline locusts is rather extensive and variable, with an almost world-wide distribution, the present collection does not contain an unusually large number of species. Aside from two or three very common forms, only a few are represented by more than two or three individuals each. The family as a whole, so far as South American forms is concerned, was somewhat fully discussed in these ANNALS (Vol. VIII, pp. 442–456) where a synoptical key for the separation of the thirty or more genera was included. Since the publication of that paper the results of studies by Mr. James A. G. Rehn, tend to somewhat modify the accepted

status of some of the representatives of the family, but not to the extent of rendering that paper useless.

Genus TRUXALIS Fabricius.

Truxalis FABRICIUS, Syst. Ent., p. 279 (1775); STÅL, Recens. Orth., I, pp. 92, 104 (1873) and many writers since.

35. **Truxalis brevicornis** (Linnæus).

Gryllus brevicornis LINN., Cent. Ins. Rar., p. 15 (1763); IB., Amœn. Acad., VI, p. 398, n. 37 (1764).

For a quite full synonymy of this species see ANNALS CARNEGIE MUSEUM, Vol. VIII, p. 9 (1911), and for the principal bibliography see Kirby's Syn. Cat. Orth., III, p. 103.

The present collection contains specimens from the following named localities; two males and 1 female, Cayenne, French Guiana, Feb. and Mch., 1917; one male, Upper Rocana, N. Pará, Brazil, July, 1918, S. M. Klages; two males, Benevides, Pará, Brazil, Oct., 1918. These different lots belong to the C. M. Acc. Nos. 5873, 6174, and 6175, respectively.

Genus EUTRYXALIS Bruner.

Eutryxalis BRUNER, 2nd Rep. Locust Comm. B. Aires, pp. 22, 24 (1900); IB., Proc. U. S. Nat. Mus., XXX, pp. 621, 625 (1906).

36. **Eutryxalis gracilis** (Giglio-Tos).

Hyalopteryx gracilis GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XII, No. 302, p. 22 (1887).

Eutryxalis gracilis BRUNER, Proc. U. S. Nat. Mus., XXX, pp. 623, 625 (1906).

Two specimens, male and female, are at hand. They were collected by Mr. J. Steinbach in the Province del Sara, Bolivia, in November and December.

Genus PARATRUXALIS Rehn.

Paratruxalis REHN, Trans. Am. Ent. Soc., XLII, pp. 275–276 (1916).

Orphula GIGLIO-TOS, BRUNER, REHN, CAUDELL, etc. during recent years (not of Stål, *teste* Rehn).

According to Rehn, *l. c.* there has been an error on the part of various recent writers as to the identity of Stål's genus *Orphula*, and he has suggested the substitution of the name *Paratruxalis* to take its place where misused.

37. **Paratruxalis filatus** (Walker).

Chrysochraon filatus WALKER, Cat. Derm. Salt. Brit. Mus., V, p. 785 (1870).
Paratruxalis filatus REHN, *l. c.*, p. 276 (1916).
Orphula pagana GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 9 (1894) *et al* (*nec* Stål).

The specimens before me, four males and four females, which I locate here, are from Quatro Ojos, Department of Santa Cruz, Province del Sara, Bolivia, and from the Rio Bermejo, Province of Salta, Argentina. They are all slightly larger than those coming from Asunción, Paraguay, and first determined by me as Stål's *Orphula pagana*. They may represent Giglio-Tos' *Orphula minor*, as suggested by Rehn (Proc. Acad. Nat. Sci., Philad., 1906, p. 17). If so, they are very closely related to *pagana*, which as shown by Rehn (Trans. Am. Ent. Soc., XLII, pp. 175–176, 1916) is the same as Walker's earlier described *Chysochraon filatus*, of which it becomes a synonym. These specimens were collected by J. Steinbach in March and April, 1913, and May, 1914.

38. **Paratruxalis filatus minor** (Giglio-Tos)?

For synonymy, etc., see Rehn, *l. c.*, pp. 175–176.

Four females coming from the Province del Sara, Bolivia, may belong here. They were taken during the period January–April, 1913, by Steinbach, and form a part of C. M. Acc. No. 5058.

Genus ORPHULELLA Giglio-Tos.

Orphulella GIGLIO-TOS, Bol. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, pp. 8, 10 (1894); BRUNER, Ann. Carnegie Mus., VIII, pp. 9–20 (1911).

The paper cited in the last reference contains a general statement concerning the genus and also a synoptic table of the South American species.

39. **Orphulella gracilis** Giglio-Tos.

Orphulella gracilis GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 11 (1894); BRUNER, Ann. Carnegie Mus., VIII, p. 11, 14 (1911).

Among the material collected by J. Steinbach in the Province del Sara, Bolivia, are four males and one female, which are referred to this species. They were taken in the months of February, March, April, and December at an approximate altitude above sea-level of 350 meters.

40. **Orphulella pelidna** (Burmeister).

Gomphocerus pelidnus BURMEISTER, Handb. Ent., II, p. 659 (1838). For further synonymy see Kirby, Syn. Cat. Orth., III, p. 120 (1910).

A number of specimens of both sexes, as well as nymphs of a member of this genus from Nueva Gerona, Columbia, and Sante Fé, Isle of Pines, West Indies, are referred here. They were chiefly taken in the months of June, July, and August. C. M. Acc. No. 4745.

41. **Orphulella peruna** Bruner.

Orphulella peruna BRUNER, Ann. Carnegie Mus., VIII, pp. 12, 16 (1911).
Zonocerus bilineatus SCUDDER, Proc. Bost. Soc. Nat. Hist., XVII, p. 268 (1874).
Orphulella ? bilineatus SCUDDER, *l. c.*, XXVII, p. 210 (1896). *Not Stenobothrus bilineatus* Scudder, Bost. Journ. Nat. Hist., VII, p. 250 (1862).

This species is represented by a pair from the Upper Mamoré River, two pairs from Las Juntas, and a single female from Quatro Ojos, all in the Department of Santa Cruz, Bolivia, collected by J. Steinbach in November and December.

42. **Orphulella punctata** (De Geer).

Acridium punctatum DE GEER, Mém. Ins., III, p. 593, pl. 42, fig. 12 (1773).
Truxalis punctata STÅL, Recens Orth., I, p. 106 (1873).
Orphulella punctata GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 12 (1894); BRUNER, Ann. Carnegie Museum, VIII, pp. 11, 15 (1911).

For a rather full synonymy of this species see Kirby, Syn. Cat. Orth., III, p. 121 (1910).

There are a number of specimens at hand of both sexes. They are from Cayenne, French Guiana, where they were taken during the months of February, March, and April by S. M. Klages. Both green or pale and dusky individuals are represented. C. M. Acc. No. 5873.

43. **Orphulella boucardi** (Bruner).

Linoceratium boucardi BRUNER, Biol. Cent. Amer., Orth., II, p. 84 (1904).
Orphulella chipmani BRUNER, Journ. N. Y. Ent. Soc., XIV, p. 149 (1906).
Linoceratium australe BRUNER, Ann. Carnegie Mus., VIII, p. 20 (1911).

For a discussion of the synonymy of the present species see James A. G. Rehn in the Transactions of the American Entomological Society, XLII, p. 277.

Specimens of this insect are at hand from Cayenne, French Guiana, taken in February and March, 1917. They belong to C. M. Acc.

Nos. 5873 and 5893; from Benevides, Pará, Brazil, taken October, 1918, C. M. Acc. No. 6174; and from the Mana River, French Guiana, May, 1917, C. M. Acc. No. 6008. They were all taken by S. M. Klages.

This material, although somewhat variable, agrees quite well with the original specimens, upon which the species was based. In color both green or greenish, and brown or fuscous specimens are included.

44. Orphulella scudderi (Bolivar)?

Orphula scudderi BOLIVAR, Mém. Soc. Zoöl. France, I, p. 142 (1888).
Orphulella scudderi BRUNER, Biol. Cent. Amer., Orth., II, pp. 77, 82 (1904); IB., Ann. Carnegie Mus., VIII, pp. 12, 17 (1911).

There is a single female specimen belonging to the genus *Orphulella* at hand, which I at first felt inclined to call new, giving it the name *O. surinama*. After considering the matter somewhat in detail it is doubtfully referred to *O. scudderi* Bolivar, originally described from Cuba, although it varies considerably from the original description of that insect. It bears the label "Cayenne, Mch. 1917, Acc. 5897."

Genus PARACHLOËBATA Bruner.

Parachloëbata BRUNER, Biol. Cent.-Amer., II, pp. 31, 86 (1902, 1904); KIRBY, Syn. Cat. Orth., III, p. 124 (1910).

The present genus was originally based on a single specimen coming from the West Indies. In general appearance this insect is very similar to the *Orphulellæ*, but differs from them in having three more spines on the outer margin of the hind tibiæ and in the color-pattern. It is also likewise more robust in stature.

45. Parachloëbata pratensis Bruner.

Parachloëbata pratensis SAUSSURE (*MS. name*); BRUNER, Biol. Cent.-Amer., Orth., II, p. 84, Pl. I, figs. 10, 10*a*, ♀ (1904); KIRBY, *l. c.*, p. 124 (1910).

The present collection contains several specimens of both sexes as well as a half dozen nymphs. They come from Nueva Gerona, Santa Fé, and Columbia, Isle of Pines, and belong to C. M. Acc. No. 4745.

In the original description of the species only the female was characterized. It is now possible to add something relative to the male. While the females vary greatly in color from almost a uniform pale grass-green with scarcely a trace of dark and pallid markings, as

originally described, to even in part vinaceous, all of the males at hand (5) are fairly uniformly colored, being greenish testaceous on the head, body, and legs. Cheeks back of the eyes, upper edges of the lateral lobes of the pronotum and the pleura fuscous; the tegmina, except the dorsal field, which is pallid, quite uniformly infuscated. The occiput, disc of the pronotum, and the dorsal area of the tegmina seem invariably to be pallid. The genicular portion of the hind femora in the males appear to be much less infuscated than in the opposite sex, where it is usually quite dark.

The following measurements can now be given: Length of body, ♂, 19 mm., ♀, 27 mm.; of pronotum, ♂, 3.3 mm., ♀, 5 mm.; of tegmina, ♂, 14 mm., ♀, 21 mm.; of hind femora, ♂, 11 mm., ♀, 15.5 mm.

Genus DICHROMORPHA Morse.

Dichromorpha MORSE, Psyche, VII, p. 326 (1896); BRUNER, Biol. Cent.-Amer., Orth., II, pp. 31, 85 (1902, 1904); IB., Second Rept. Locust. Com. B. Aires, p. 28 (1900); IB., Ann. Carnegie Mus., VIII, pp. 444, 449 (1911).

The representatives of the genus *Dichromorpha* all belong to the Western Hemisphere, where they are to be met with at suitable localities between, the 50th parallel north, and about the 40th parallel south.

46. **Dichromorpha australis** Bruner.

Dichromorpha australis BRUNER, Locusts of Argent., p. 29 (1900); IB., Ann. Carnegie Mus., VIII, p. 449 (1911).

Dichromorpha viridis GIGLIO-TOS (*nec* Scudder), Boll. Mus. Zoöl. Anat. Comp. Torino, XII, no. 302, p. 24 (1897).

A single male specimen coming from the Rio Japacani in eastern Bolivia is among the material collected by J. Steinbach in February, 1915. C. M. Acc. No. 5573.

Nearly all of the specimens of this species are pale testaceous, rather than green, the prevailing color of our North American *D. viridis*. In *D. australis* a much larger percentage of the individuals are also brachypterous than is the case in *D. viridis*.

Genus FENESTRA Giglio-Tos.

Fenestra GIGLIO-TOS, Zoöl. Jahrb., Syst. Abth., VIII, p. 807 (1895); REHN, Proc. Acad. Nat. Sci. Phil., 1906, p. 31.

Dichroaletttix BRUNER, 2nd Rept. B. Aires Locust Comm., pp. 22, 32 (1900).

Not = *Fenestra* BRUNNER VON WATTENWYL, Revis. Syst. Orth., p. 120 (1893), which evidently was based on a species of Rehn's genus *Cocytolettix*. (See discussion by Rehn in footnote No. 12, p. 30, Proc. Acad. Nat. Sci. Phil., 1906.)

47. **Fenestra bohlsii** Giglio-Tos.

Fenestra bohlsii GIGLIO-TOS, Zoöl. Jahrb., Syst. Abth., VIII, p. 807 (1895); REHN, *l. c.*, p. 32 (1906).

The material collected by Steinbach in March and April, 1913, contains a single female from the Province del Sara, Bolivia, which I refer here. It was taken at an altitude of 350 meters above sea-level. There are also at hand two males coming from Buena Vista, and one from the Rio Japacani of eastern Bolivia. The latter specimen was taken in February, 1915. All these males were collected by J. Steinbach. C. M. Acc. No. 5573.

Genus PERUVIA Scudder.

Peruvia SCUDDER, Psyche, V, p. 439 (Dec. 1890); REHN, Trans. Amer. Ent. Soc., XLII, p. 280 (1916).

Toxopterus BOLIVAR (*nec* Koch), Anal. Soc. Esp. Hist. Nat., XIX, p. 313 (1890).

The present genus unfortunately has had a checkered career, as may be seen by referring to the synonymy under the species *Peruvia nigromarginata* Scudder, which follows. Mr. Jas. A. G. Rehn has discussed the synonymy rather carefully (*l. c.*, pp. 280, 281).

48. **Peruvia nigromarginata** (Scudder).

Machærocera nigromarginata SCUDDER, Proc. Bost. Soc. Nat. Hist., XVII, p. 268 (1875).

Peruvia nigromarginata SCUDDER, Psyche, V, p. 439 (Dec. 1890); REHN, Trans. Amer. Ent. Soc., XLII, p. 280 (1916).

Toxopterus miniatus BOLIVAR, Anal. Soc. Esp. Hist. Nat., XIX, p. 314 (Feb. 1891).

While the present material does not happen to contain representatives of this insect, it is a denizen of eastern Bolivia so frequently referred to in these pages, and from which the Carnegie Museum contains specimens, there collected.

Genus AMBLYTROPIDIA Stål.

Amblytropidia STÅL, Recens. Orth., I, pp. 93, 107 (1873); BRUNER, Ann. Carnegie Mus., VIII, p. 24 (1911). For a more complete bibliography see Kirby, Syn. Cat. Orth., III, p. 114 (1910).

49. **Amblytropidia corumbæ** Bruner.

Amblytropidia corumbæ BRUNER, Ann. Carnegie Mus., VIII, pp. 25, 28 (1911).

There certainly is in the material from the Province del Sara, Bolivia, one female, and possibly three others belonging here. They were

collected by J. Steinbach in October and December. One of these three, taken in December, differs quite noticeably from the others in not only having the tegmina destitute of the pale sub-costal line, but also quite uniformly rather prominently conspersed with fuscous. Otherwise they agree fairly well with *A. corumbæ*.

50. **Amblytropidia chapadensis** Rehn.

Amblytropidia chapadensis REHN, Proc. U. S. Nat. Mus., XXX, p. 371 (1906); BRUNER, Ann. Carnegie Mus., VIII, pp. 25, 29, 451 (1911, 1913).

Only a single male specimen among the present lot of orthopterous insects is referable to *A. chapadensis*. It is from Buena Vista, eastern Bolivia, where it was taken by J. Steinbach. C. M. Acc. No. 5573.

51. **Amblytropidia trinitatis** Bruner.

Amblytropidia trinitatis BRUNER, Biol. Cent.-Amer., Orth., II, p. 65 (1904); IB., Proc. U. S. Nat. Mus., XXX, p. 630 (1906); IB., Ann. Carnegie Mus., VIII, p. 25 (1911).

I now have before me five males and three females of this interesting little species, little, at least so far as the male is concerned. They come from Cayenne, French Guiana, where they were taken in January, February, and March, 1917, by S. M. Klages. C. M. Acc. No. 5873.

This insect is interesting from the fact that the males have the basal half of the wings very noticeably tinted with a delicate rose-pink. In the females this tint is scarcely visible, except at the very base, where it is confined to the anterior margin.

52. **Amblytropidia robusta** Bruner.

Amblytropidia robusta BRUNER, Proc. U. S. Nat. Mus., XXX, p. 371 (1906); IB., Ann. Carnegie Mus., VIII, pp. 25, 28 (1911).

A pair, male and female, taken by J. Steinbach at Buena Vista, eastern Bolivia, are here referable. C. M. Acc. No. 5573.

Genus BORELLIA Rehn.

Borellia REHN, Proc. U. S. Nat. Mus., XXX, p. 379 (1906); BRUNER, Ann. Carnegie Mus., VIII, pp. 34 (1911), 446 (1913).

53. **Borellia carinata** Rehn.

Borellia carinata REHN, *l. c.*, p. 379 (1906); BRUNER, Ann. Carnegie Mus., VIII, p. 34 (1911).

Only a single male specimen coming from the Province del Saral Bolivia is referred here. It was collected by Steinbach at an elevation of 450 meters above sea-level. It is quite typical, and agrees well, with the large series examined by me and reported upon in a previous paper appearing in the ANNALS, Vol. VIII, p. 34.

Genus STAURORHECTUS Giglio-Tos.

Staurorhectus GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp., XII, no. 302, p. 25 (1897); BRUNER, Ann. Carnegie Mus., VIII, p. 31 (1911).

54. **Staurorhectus longicornis** Giglio-Tos.

Staurorhectus longicornis GIGLIO-TOS, *l. c.*, p. 26 (1997); BRUNER, *l. c.*, p. 31 (1911).

The collection contains three specimens of this locust, two males from the Province del Sara, Bolivia, and a female, the latter from the Rio Bermejo, Province of Salta, Argentina. They were taken in February, March, and April by J. Steinbach.

While the males of this species are quite uniform as to color, the females are apt to vary greatly in this respect.

Genus COMPSACRIS Bolivar.

Compsacris BOLIVAR, Anal. Soc. Españ. Hist. Nat., XIX, p. 315 (1890); REHN, Trans. Amer. Ent. Soc., XLII, p. 279 (1906); BRUNER, Ann. Carnegie Mus., VIII, p. 445 (1913).

This genus comes near to *Staurorhectus* Giglio-Tos, but is distinct. It belongs to the region of the upper Amazons in eastern Bolivia and southwestern Brazil.

55. **Compsacris pulcher** Bolivar.

Compsacris pulcher BOLIVAR, *l. c.*, p. 315 (1890); REHN, Trans. Amer. Ent. Soc., XLII, p. 279 (1916).

Staurorhectus intermedius BRUNER, Ann. Carnegie Mus., VIII, p. 31 (1911).

The present collection contains two males and a female of this species. They come from Benevides, Pará, Brazil, where they were taken by S. M. Klages in October, 1918. C. M. Acc. No. 6174.

The males and females of this insect agree with the female of my *Amblyscapheus lineatus* from Paraguay in having the apical joints of the antennæ white or pallid; but the valves of the ovipositor are very unlike those of *A. lineatus*.

Genus ALOTA Bruner.

Alota BRUNER, Ann. Carnegie Mus., VIII, pp. 446, 454 (1911).

The genus *Alota* was established by the present writer on the strength of a single male specimen from the Rio Machupo in Bolivia. It belongs to the group *Scyllininæ* as shown by the size and form of the inner hind tibial spurs.

56. **Alota boliviana** Bruner.

Alota boliviana BRUNER, *l. c.*, p. 454 (1911).

This species was described, as stated above, from a single male specimen.

We now have a female which also belongs here. It was taken by J. Steinbach at Las Juntas, in the Department of Santa Cruz, Bolivia, in December, 1913, at an altitude of 250 M. above sea-level. C. M. Acc. No. 5060.

This specimen in its type of coloration and general appearance at first glance recalls one of the larger species of *Orphulella*, and also of the representatives of the genus *Parorphula*. However, the entire absence of lateral pronotal carinæ and the structure of the tibial spurs at once carry it to *Alota* in the synoptic table of the South American genera of the Truxalidæ. The tegmina have the costal and discal fields infuscated, the former varied with a series of pale spots, which give to that area a longitudinal maculate appearance. This female specimen has but six spines on the outer margin of the hind tibiæ instead of seven, as described for the male type. Still I feel satisfied that it belongs to the species *boliviana*.

Length of body, ♀, 19 mm.; of pronotum, 3.85 mm.; of tegmina, 19 mm.; of hind femora, 12 mm.

Genus SCYLLINA Stål.

Scyllina STÅL, Recens. Orth., I, pp. 94, 112 (1873). For further synonymy see Annals VIII, p. 35 (1811).

This is certainly an important genus in tropical American countries, where its representatives are widely distributed and among the most abundant of locusts. Some of them even become destructive to crops and forage-plants in their respective localities.

57. **Scyllina brunneri** (Giglio-Tos).

Pseudostauronotus brunneri GIGLIO-TOS, Zoöl. Jahrb., Syst., VIII, p. 800 (1895).

Plectorotettix brunneri BRUNER, Biol. Cent.-Amer., Orth., II, p. 100 (1904); IB., Proc. U. S. Nat. Mus., XXX, p. 636 (1906).

Scyllina brunneri REHN, Proc. U. S. Nat. Mus., XXX, p. 385 (1906).

The only specimen at hand which is referable to Giglio-Tos's *brunneri* is a male taken at a point in the Province del Sara, Bolivia, at an elevation of 350 m. above sea-level. It was collected by J. Steinbach in November, 1913.

58. **Scyllina smithi** Rehn?

Scyllina smithi REHN, Proc. U. S. Nat. Mus., XXX, pp. 387–388 (1906); BRUNER, Ann. Carnegie Mus., VIII, p. 36 (1911).

There are six males and six females in the collection, which are with some doubt referred to Rehn's *S. smithi*. They were collected by J. Steinbach in the Province del Sara, Bolivia, in October and November, 1913.

59. **Scyllina borellii** Giglio-Tos?

Scyllina borelli GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 14 (1894).

Mr. Steinbach took a remarkably large male *Scyllina* in the Province del Sara, which I am inclined to refer to *S. borellii* of Giglio-Tos, only the female of which was described. Rehn later described his female *S. schistocercoides*, which is also very large, but not any larger than the present specimen. Rehn's specimen was rather slender, while that of Steinbach's collecting is comparatively robust.

The present specimen was found at an elevation of 350 meters above sea-level. It measures; Length of body, 37 mm.; of pronotum, 7 mm.; of tegmina, 37 mm.; of hind femora, 25 mm.

60. **Scyllina cyanipes** (Fabricius)?

Gryllus cyanipes FABRICIUS, Syst. Ent., p. 292, no. 25 (1775).
Scyllina cyanipes KIRBY, Syn. Cat. Orth., III, p. 132 (1910).

One male and two females of an insect belonging to *Scyllina* and coming from Cayenne, French Guiana, are referred here with some hesitation. They were collected in the month of February, 1917, and are included in C. M. Acc. No. 5873.

61. **Scyllina pratensis** (Bruner)?

Plectrotettix pratensis BRUNER, Biol. Cent.-Amer., Orth., II, p. 100 (1904).
Scyllina pratensis REHN, Proc. Acad. Nat. Sci., LVIII, p. 45 (1906).

A single male *Scyllina* coming from the Rio Japacani of eastern

Bolivia is referred with some doubt to this species, because of its being taken so far from the given habitat of the species, and because no specimens of *pratensis* are at hand for comparison. The insect was taken by J. Steinbach in February, 1915. C. M. Acc. No. 5873.

62. **Scyllina brasiliensis** (Bruner).

Plectrotettix brasiliensis BRUNER, Biol. Cent.-Amer., Orth., II, p. 100 (1904).
Scyllina brasiliensis REHN, *l. c.*, p. 46 (1906).

Four males and three females of a second *Scyllina* coming from Cayenne in French Guiana are referred here. These were collected in February and March, 1917. C. M. Acc. Nos. 5873 and 5897.

Family ŒDIPODIDÆ.

Genus CHORTOPHAGA Saussure.

Chortophaga SAUSSURE, Mém. Soc. Génève, XXVIII (9), pp. 43, 72 (1884). For further synonymy see KIRBY, Syn. Cat. Orth., III, p. 198.

63. **Chortophaga cubensis** (Scudder).

Tragocephala cubensis SCUDDER, Proc. Bost. Soc. Nat. Hist., XVII, pp. 480, 483 (1875).
Chortophaga cubensis SAUSSURE, Mém. Soc. Génève, XXVIII (9), pp. 72, 73 (1884), etc.

There are four females of this species before me. They form part of C. M. Acc. No. 4798, and were collected at Los Indios and Nueva Gerona on the Isle of Pines.

Genus PSINIDIA Stål.

Psinidia STÅL, Recens. Orth., I, pp. 117, 133 (1873). For a rather extended synonymy see KIRBY, Syn. Cat. Orth., III, p. 246 (1910).

64. **Psinidia fenestralis** (Serville).

Œdipoda fenestralis SERVILLE, Ins. Orth., p. 726 (1838); THOMAS, Synopsis Acrid. N. Amer., pp. 109, 118 (1873).
Psinidia fenestralis STÅL, *l. c.*, p. 133 (1873).

This rather common Œdipodid is represented by one male, two females and two nymphs. They come from Los Indios and Nueva Gerona, Isle of Pines.

This same species is quite widely distributed on the North American continent, and occurs with both red and yellow hind-wings. It is

an insect of the seashore and sandy beaches of inland waters, extending even into Canadian territory to the north of the United States and southward into Mexico.

Genus SPHINGONOTUS Fieber.

Sphingonotus FIEBER, Lotus, III, p. 124 (1853); SAUSSURE, Mém. Soc. Génève, XXVIII, pp. 60, 195 (1884). For a more complete synonymy see KIRBY, Syn. Cat. Orth., III, p. 271 (1910).

65. **Sphingonotus cærulans cubensis** Saussure.

Sphingonotus cærulans var. *cubensis* SAUSSURE, Prodrom. Œdip., p. 201 (1884); REHN, 2nd Rept. Cent. Exp. Sta. Cuba, p. 204 (1909).

A single male specimen of this West Indian variety of the European *S. cœrulans* is at hand. It comes from Nueva Gerona, Isle of Pines. It was taken on August 10, 1912, and forms a part of C. M. Acc. No. 4745.

Family OMMEXECHIDÆ.

Genus OMMEXECHA Serville.

Ommexecha SERVILLE, Ann. Sci. Nat., XXII, p. 285 (1831); BLANCHARD, Ann. Soc. Ent. France, V, p. 607 (1836); BOLIVAR, An. Soc. Españ. Hist. Nat., pp. 21, 27, 493 (1884). For a more complete synonymy see KIRBY, Syn. Cat. Orth., III, p. 296 (1910).

66. **Ommexecha servillei** Blanchard.

Ommexecha servillei BLANCHARD, Ann. Ent. Soc. France, V, p. 613, pl. 22, figs. 2, 3 (1836).

The material collected by Mr. J. Steinbach at an elevation of 350 meters above sea-level in the Province del Sara, Bolivia, contains two female specimens of this species.

67. **Ommexecha macropterum** Blanchard.

Ommexecha macropterum BLANCHARD, Monog. Ommex., p. 610, pl. 21, figs. 3, 4 (1836).

A single male and five females from the Province del Sara, and two males from Las Juntas, Department of Santa Cruz, Bolivia, are referred here. The former lot were taken at an elevation of 350 meters, and the latter at 250 meters above sea-level. They were all collected by J. Steinbach in the months of February and December, 1913.

Family PYRGOMORPHIDÆ.

Genus OMURA Walker.

Omura WALKER, Cat. Derm. Salt. Brit. Mus., III, p. 503 (1870); BOLIVAR, An. Soc. Españ. Hist. Nat., V, p. 215 (1905); IB., Gen. Ins., Fasc. 90. Orth. Acrid., Pyrg., pp. 39, 41 (1909).

Protomachus STÅL, Bihang. Svensk, Akad. Handl., IV (5), p. 53 (1776); BOLIVAR, An. Soc. Españ. Hist. Nat., XIII, pp. 23, 60, 494 (1884).

68. **Omura congrua** Walker.

Omura congrua WALKER, *l. c.*, p. 504 (1870); BOLIVAR, Gen. Ins., Fasc. 90, Orth. Acrid., Pyrg., p. 41, pl. 1, figs. 5, 5*a* (1909).

Protomachus depressus STÅL, *l. c.*, p. 54 (1876); BOLIVAR, An. Soc. Españ. Hist. Nat., XIII, pp. 61, 494, pl. 1, fig. 7 (1884).

A pair, male and female, of this peculiar locust are before me. They come from Pied Saut, Oyapok River, in French Guiana, where they were collected by S. M. Klages in November, 1917. C. M. Acc. No. 6111.

Family CYRTACANTHACRIDÆ.

Genus PROCOLPIA Stål.

Procolpia STÅL, Recens. Orth., I, pp. 28, 45 (1873); GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XIII, no. 311, p. 41 (1898); BRUNER, Proc. U. S. Nat. Mus., XXX, pp. 640, 643 (1906).

69. **Procolpia minor** Giglio-Tos.

Procolpia minor GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 17 (1894); REHN, Proc. Acad. Nat. Sci. Philad., LIX, p. 169 (1907); BRUNER, Proc. U. S. Nat. Mus., XXX, p. 643 (1906).

Munatia australis BRUNER, Proc. U. S. Nat. Mus., XXX, p. 644 (1906).

The present collection contains one male from Buena Vista and a female from the Rio Japacani district of eastern Bolivia. They were taken by J. Steinbach in the spring of 1915. C. M. Acc. No. 5573.

70. **Procolpia emarginata** (Serville).

Xiphicera emarginata SERVILLE, Ann. Sci. Nat., XXII, p. 271 (1832).

Procolpia emarginata STÅL, *l. c.*, p. 45 (1873); BRUNER, Biol. Cent.-Amer., Orth. II, p. 223 (1907).

The collection contains a single female specimen which belongs here. It was taken at Quatro Ojos, Department of Santa Cruz, Bolivia, by J. Steinbach.

Genus PRORHACHIS Scudder.

Prorhachis SCUDDER, Proc. Bost. Soc. Nat. Hist., XVII, p. 269 (1875); GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XIII, no. 311, p. 40 (1878).

71. **Prorhachis granulosa** Scudder?

Prorhachis granulosa SCUDDER, *l. c.*, p. 269 (1875).

One male from Las Juntas, Department of Santa Cruz, and one female from the Province del Sara, Bolivia, are referred to Scudder's species. The former was collected in December and the latter in either March or April of the same year. In addition there are two rather young nymphs, which also seem likely to belong here. The latter come from Las Juntas, in the Department of Santa Cruz. They, together with the male, are part of C. M. Acc. No. 5060; while the female belongs to C. M. Acc. No. 5058. They were all taken by J. Steinbach.

The young nymphs have the median pronotal carina greatly arched and deeply notched.

Genus ÆOLACRIS Scudder.

Æolacris SCUDDER, Proc. Bost. Soc. Nat. Hist., XVII, p. 269, note (1875); PICT. & SAUSS., Mitth. Schweiz. Ent. Ges., VII, p. 340 (1887); GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XIII, no. 311, p. 41 (1898); BRUNER, Biol Cent.-Amer., Orth., II, pp. 209, 224 (1907).

72. **Æolacris caternaulti** (Feisthamel).

Xiphicera caternaultii FEISTH., Mag. Zoöl., VII (9), pl. 184 (1837).
Xiphicera octolunata SERVILLE, Ins. Orth., p. 615, no. 5 (1839).
Æolacris caternaultii PICT. & SAUSS., *l. c.*, p. 340, no. 2 (1887); GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XII, no. 301, p. 3 (1897).
Xiphicera octomaculata SCUDDER, Proc. Bost. Soc. Nat. Hist., XII, p. 337, no. 16 (1869).

A single female coming from the Mana River district in French Guiana belongs here. It was taken in May, 1917. C. M. Acc. No. 6008.

Genus PRIONOLOPHA Stål.

For a bibliography and synonymy of this genus see Kirby, Syn., Cat. Orth., III, pp. 358 and 359. Only the one species is known. Nevertheless it has been described many times, as indicated by the extensive synonymy (*l. c.*, pp. 358–359).

73. **Prionolopha serrata** (Linnæus).

A pair, male and female, are contained in the material coming from Cayenne, French Guiana. They were taken in February, 1917, and belong to C. M. Acc. No. 5873.

Genus COLPOLOPHA Stål.

Colpolopha STÅL, Œfv. Vet.-Akad. Förh., XXX (4), p. 53 (1873). See Kirby, Syn. Cat. Orth., III, p. 362, for additional bibliography.

74. **Colpolopha obsoleta** (Serville).

Tropinotus obsoletus SERVILLE, Ann. Sci. Nat., XXII, p. 274 (1831); IB., Ins. Orth., p. 620 (1839).

Colpolopha obsoleta PICT. & SAUSS., Mitt. Schweiz. Ent. Ges., VII, p. 338 (1887).

Xiphocera basalis WALKER, Cat. Derm. Salt. Brit. Mus., III, p. 522 (1870).

The collections made by S. M. Klages on the Mana River of French Guiana during July, 1917, contain five males and four females of this locust. They are a part of C. M. Acc. No. 5008.

Genus CORYACRIS Rehn.

Coryacris REHN, Proc. U. S. Nat. Mus., XXXVI, p. 111 (1909); BRUNER, Ann. Carnegie Mus., VIII, pp. 53, 462 (1913).

75. **Coryacris angustipennis** (Bruner).

Elæochlora angustipennis BRUNER, 2nd Rept. Locust. Comm. B. Aires, p. 58 (1900).

Coryacris diversipes REHN, Proc. U. S. Nat. Mus., XXXVI, pp. 111–114, figs. 1, 2 (1909).

Two females were collected by J. Steinbach in the Province del Sara, Bolivia, in November, 1912, and in December, 1913, at an elevation of 350 meters above sea-level.

Genus ZONIOPODA Stål.

Zoniopoda STÅL, Recens. Orth., I, pp. 32, 51 (1873); BRUNER, Proc. U. S. Nat. Mus., XXX, p. 652 (1906); IB., Ann. Carnegie Mus., VIII, p. 57 (1911).

76. **Zoniopoda tarsata** (Serville).

Acridium tarsata SERVILLE, Ann. Sci. Nat., XXII, p. 283 (1831).

Zoniopoda tarsata STÅL, Recens. Orth., I, p. 51 (1873); BRUNER, Ann. Carnegie Mus., VIII, pp. 57, 59 (1911).

The material now being studied contains a single female specimen,

taken by Steinbach in the Province del Sara, Bolivia, at an elevation of 350 meters above sea-level, collected February, 1913. C. M. Acc. No. 5058. A male and a female were also taken by Steinbach at Buena Vista. C. M. Acc. No. 5573.

Mr. James A. G. Rehn at one time regarded *Z. cruentata* (Blanchard) as being distinct from *tarsata* (see Proc. Acad. Nat. Sci. Phil., LIX, p. 175, 1907). More recently, however, he thinks that they only represent geographic races, or merely environmental phases of a single species. (Trans. Am. Ent. Soc., XLIV, p. 202, 1918.)

Genus OPTHALMOLAMPIS Saussure.

Opthalmolampis SAUSSURE, Rev. Zoöl., (2), XI, p. 394 (1859); STÅL, Bihang till Svensk. Akad. Handl., V, p. 42 (1878); BRUNER, Ann. Carnegie Mus., VIII, p. 476 (1913).

77. **Ophthalmolampis geniculapicta** sp. nov.

Among the described species, as shown by the synoptical key prepared by me and published in the ANNALS, Vol. VIII, pp. 476–477, this form is most nearly related to *O. geniculata* Stål. It is a medium-sized insect with two narrow, interrupted, pale longitudinal lines on the sides of the pronotum, the one above bounding the disc on its outer margin, and the other located about two-thirds of the distance towards the lower margin. Hind femora with the geniculæ black, ornamented by three large orange-red maculæ, two of which are situated on the sides and the other above. The hind tibiæ at their base also are provided with a prominent macula of the same color.

Head of moderate size, about as wide as the front edge of the pronotum, into which it fits almost to the eyes; the occiput but little, if any, elevated, very coarsely and deeply pitted or punctured, as are the front, cheeks, pronotum, and sides of both the meso- and metathorax. Vertex narrow, depressed between the upper portion of the prominent eyes, but little wider than one-half the diameter of the basal antennal joint, the fastigium widely and roundly sulcate, the frontal costa not prominent, as wide above the antennæ as the fastigium, not sulcate, but coarsely pitted, a little narrowing anteriorly and terminating at the ocellus, which is located at a point a little in advance of a line drawn across the front at the lower edge of the antennal sockets. Antennæ rather slender, about as long as the hind femora, in nowise ensiform, but with all the segments slightly flattened.

Anterior and middle legs only moderately robust, of normal length; the hind femora decidedly robust and with all the carina strongly spinoso-tuberculate; the hind tibiæ seven-spined on both edges, about 1.5 mm. shorter than the hind femora; the three tarsal joints of about equal length, and very hirsute. Tegmina much abbreviated, less than one-half the length of the abdomen, their upper edges a trifle overlapping at the apex.

General color of insect flavo-olivaceous, the antennæ vinaceous red, with a tinge of black along the middle of the upper side of their basal half-dozen joints or segments. Face, from the base of the antennæ along the lower margin of the eyes and diagonally across the cheeks, as well as the sides of the occiput to its hind border, also the base of the clypeus, and the lower margin of the front, white-lined, these lines apparently in continuation of the pronotal vitta. Tegmina each with two longitudinal white lines. Eyes æneous. Hind tarsi rubro-testaceous.

Length of body, ♀, 26 mm.; of pronotum, 6.25 mm.; of tegmina, 7 mm.

Habitat: The type of this interesting species bears the label "Prov. del Sara, Bolivia, 350 M., J. Steinbach." C. M. Acc. No. 5058.

78. **Opthalmolampis albolineata** Bruner.

Opthalmolampis albolineata BRUNER, Ann. Carnegie Mus., VIII, pp. 476, 477–478 (1913).

A single specimen of this species is at hand. It was collected by J. Steinbach in December, 1913, at Las Juntas in the Department of Santa Cruz, Bolivia, at 250 M. above sea-level. C. M. Acc. No. 5060.

Genus TRYBLIOPHORUS Serville.

Trybliophorus SERVILLE, Ann. Sci. Nat., XXII, p. 274 (1831); IB., Ins. Orth., p. 631 (1839); KIRBY, Syn. Cat. Orth., III, p. 392 (1910); BRUNER, Biol. Cent.-Amer., Orth., II, pp. 212, 251 (1907–8). For additional bibliography see Kirby, *l. c.*

79. **Trybliophorus octomaculatus** Serville.

Trybliophorus octomaculatus SERVILLE, *ll. cc.*, p. 275 (1831), p. 632 (1839); BURMEISTER, Handb. Ent., II, p. 618 (1839).

A pair of this highly colored locust are at hand from Pied Saut, Oyapok River, French Guiana, where they were collected by S. M. Klages in November, 1917. C. M. Acc. No. 6111.

80. **Trybliophorus modestus** sp. nov.

Quite small, a somewhat robust, and dull and plainly colored insect for a member of this genus, but with the definitely produced hind border of the disc of the pronotum and the strongly roughened and serrated hind femora, so characteristic of other members of the genus.

Antennæ robust, pallid, or faintly testaceo-ferruginous, the basal joints flattened and quite wide, gradually narrowing apically and giving to them an ensiform appearance, when compared with the filiform structure of these members, as they are in the remainder of the described species. Head of the usual form, the eyes large and prominent, the vertex narrow, about half the width of the basal antennal joint; the fastigium of the vertex depressed, a little longer than wide, linearly sulcate, but with coarse lateral walls. Frontal costa plane, prominent, and broad between the antennæ, narrowly sulcate and suddenly much lower below the ocellus, not quite reaching the clypeus; viewed laterally broadly rounded between the antennæ. Front rugulose, not punctulate, as in *T. octomaculatus*, and its allies; occiput also faintly and sparsely pitted. Pronotum rather robust and punctulate, the anterior lobe subcylindrical, but little expanding caudad; the posterior lobe a little expanding, hind margin of the disc produced at middle, but somewhat shorter, and with the apex a little more rounded than usual. Tegmina and wings somewhat abbreviated, about four-fifths the length of the abdomen. Hind femora robust, extending beyond the tip of the abdomen nearly as much as the length of the geniculæ, the tibiæ six-spined externally, rather strongly hirsute; the first and second tarsal joints about equal in length. Tip of the male abdomen acuminate and a little upturned; the cerci finger-like, directed upward and a little to the rear, about five times as long as wide at their base, a little narrower on their apical fourth and acuminate. Prosternal spine robust, short, blunt, a little transverse.

General color pale brunneo-testaceous, sides of the head back of the eyes, the upper fourth of the lateral lobes of the pronotum and the disc, and the costal fields of the tegmina longitudinally vittate with piceous, on the tegmina divided by a narrow pallid line. Genicular lunules, or arcs, and bases of the tibiæ infuscated. Antennæ a little darker than the prevailing color of the insect. Legs concolorous, the genicular lobes more pallid.

Length of body, ♂, 20 mm.; of pronotum, 7 mm.; of tegmina, 9 mm.; of hind femora, 12.5 mm.

Habitat: The only specimen at hand, a male, and the type of the species, comes from Buena Vista, eastern Bolivia, where it was taken by J. Steinbach. C. M. Acc. No. 5573.

Genus PRORACHTHES Gerstæcker.

Prorachthes GERSTÆCKER, Mitth. Ver. Neu-Vorpomm. u. Rügen, XX, p. 38 (1889).
Prorachtes GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XIII, no. 311, p. 44 (1898).

The present genus was erected to receive a very peculiar elongate cylindrical locust coming from Peru.

81. **Prorachthes insignis** Gerstæcker.

Prorachthes insignis GERSTÆCKER, *l. c.*, p. 40 (1889).

A single male specimen of this remarkable locust is at hand. It comes from the Rio Japacani of eastern Bolivia, where it was taken in February 1917, by J. Steinbach. It bears no accession number, but undoubtedly should be included in Acc. No. 5573.

As Gerstaecker's description was based only on the female sex, a few additional features possessed by the male may be noted here. In this sex the vertex in front of the eyes is almost cylindrical, narrowing but little towards the front, linearly grooved in the middle above and below, with the frontal costa raised in the form of an elevated wall, which is linearly sulcate from its middle to the base of the clypeus. The latter has its basal middle triangularly set into the front. The median ocellus is located just opposite the anterior margin of the eyes, while the lateral ocelli are situated in front of the middle of the eyes, and a very little in advance of them and appear as small, smooth, rounded warts. The last ventral segment of the male abdomen is greatly elongate and dagger-like.

Length of body, ♂, 61 mm.; of vertex in front of the eyes, 7.5 mm.; of pronotum, 6 mm.; of tegmina, 31 mm.; of hind femora, 20 mm.; of last ventral segment of abdomen, 11 mm. The antennæ of the specimen are imperfect.

Genus LEPTYSMA Stål.

Leptysma STÄL, Recens. Orth., I, pp. 42, 85 (1873); BRUNER, Proc. U. S. Nat. Mus., XXX, p. 657 (1906); IB., Ann. Carnegie Mus., VIII, pp. 71 (1911), 478 (1913).

As suggested on page 71 of Vol. VIII of the ANNALS, the present genus contains at least a dozen and a half distinct, though rather closely related forms, which occur in tropical and subtropical America. Some of these already have been described, but others not. The principal reason for this state of affairs seems to be due chiefly to the lack of the necessary material at any one time, as well as the difficulty of definitely determining the identity of the species described by Burmeister, Serville, and Thunberg. The present collection certainly contains three forms, or possibly five. They belong to C. M. Acc. No. 5058. They seem to be separable as given under Nos. 82–86 inclusive.

82. **Leptysma gracilis** Bruner.

Leptysma gracilis BRUNER, Proc. U. S. Nat. Mus., XXX, p. 658 (1906); IB., Ann. Carnegie Mus., VIII, p. 71 (1911).

The material collected by J. Steinbach in the Province del Sara, Bolivia, contains two males of this delicate little species. They were taken in October, 1913, at an elevation of 350 meters above sea-level. C. M. Acc. No. 5058. Two others taken by the same collector bear the label "Rio Japacani, E. Bolivia, February 1917. C. M. Acc. No. 5573."

83. **Leptysma filiformis** (Serville).

Opsomala filiformis SERVILLE, Ins. Orth., p. 503 (1839).

Leptysma filiformis STÅL, Recens. Orth., I, p. 85 (1873); BRUNER, Proc. U. S. Nat. Mus., XXX, p. 658 (1906); IB., Ann. Carnegie Mus., VIII, p. 72 (1911).

Five males and six females seem to belong to *Opsomala filiformis* Serville, as I have determined that species. They all come from the Province del Sara, Bolivia, where they were collected by J. Steinbach in October, 1913, at an elevation of 350 meters above sea-level. C. M. Acc. No. 5058.

84. **Leptysma** sp. No. 1

Two males and possibly a female of a form which seems to be distinct from *L. filiformis*, are set aside as species No. 1. They are a little smaller and somewhat slenderer than the specimens referred to *L. filiformis*. They do not have the abdomen dusky above, and have the fastigium larger and longer than in the individuals assigned to No. 83. They measure as follows: Length of body, ♂, 33 mm.,

♀, 38 mm.; of pronotum, ♂, 4.5 mm., ♀, 5.1 mm.; of tegmina, ♂, 31 mm., ♀, 37 mm.; of hind femora, ♂, 13 mm., ♀, 15 mm.

Habitat: Province del Sara, Bolivia; taken October, 1913, by J. Steinbach. C. M. Acc. No. 5058.

85. **Leptysma** sp. No. 2.

A single female taken in October by the same collector and coming from the same locality as the two preceding is set aside as possibly representing still another species. It is about the size of the *L. filiformis,* recorded above. The most noticeable differences are in the paler, almost uniform, color of the abdomen, sides of the head, and the lower margin of the thorax. In this specimen the fastigium of the vertex is a little longer and broader, while the eyes are a trifle less prominent than in *L. filiformis.* It is similar to, and may be the same as, the insect described by me in a former volume of the ANNALS (VIII, p. 72) as *L. intermedia.* This, of course, is only conjecture, since the type of that species is not at hand for comparison. This insect belongs to the same accession as *Leptysma* No. 1.

86. **Leptysma** sp. No. 3.

A fifth well-marked form is represented by a single female, which recalls the species *L. grossa* described by the present writer in the ANNALS, Vol. VIII, pp. 74–75. The present specimen, while quite gross in the structure of its head and thorax, is considerably smaller than the insect with which it is compared. It measures 48 mm. in length, with the head only 11 mm. instead of 12.5 mm. long.

Habitat: The insect is from the Province del Sara, Bolivia, taken at an elevation of 350 meters above the sea, by J. Steinbach in October, 1913. C. M. Acc. No. 5058.

Genus LEPTYSMINA Giglio-Tos.

Leptysmina GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 34 (1894), XIII, no. 311, p. 44 (1898); BRUNER, 2d Rept. Locust Comm. B. Aires, pp. 53, 65 (1900); IB., Journ. N. Y. Ent. Soc., XIV, p. 151 (1906); IB., Proc. U. S. Nat. Mus., XXX, pp. 641, 658 (1906).

The genus *Leptysmina* contains two described forms, and apparently a third, if the specimen among the material now being studied is distinct from *pallida,* as it seems to be.

87. **Leptysmina minor** sp. nov.

Similar to, but smaller and somewhat slenderer than *L. pallida* and *L. rosea* of Giglio-Tos, but most nearly resembling the latter in its general color, if my material is correctly determined.

Comparatively slender, the head elongate, with the occiput on nearly the same plane as the pronotum; the fastigium of the vertex with the sides nearly parallel, and with its apex broadly rounded, the median and accessory carinæ prominent and with the intervening sulci profound. Antennæ strongly ensiform and decidedly longer than the head. Vertex narrow, but little wider than the diameter of the second antennal joint, heavily longitudinally carinated in the middle, and lightly but acutely carinated at its sides. Pronotum subcylindrical, plainly widening cephalad, the median carina fairly prominent throughout, the transverse sulci plainly visible, but not profound. Tegmina somewhat mutilated near their base, but surpassing the tip of the abdomen. Hind tibiæ thirteen-spined externally, seventeen-spined internally.

General color above pale ferrugineo-testaceous; legs, front, and under side pale grass-green. Cheeks, lower portion of the sides of pronotum, and the pleura, longitudinally striped with creamy white, above which is a stripe of a fusco-olivaceous tinge, which gradually merges into the general dorsal hue. Antennæ ferruginous, the eyes castaneous, with a brassy hue or luster in certain lights.

Length of body, ♀, 37 mm.; of head in advance of the pronotum, 8 mm.; of pronotum 6 mm.; of tegmina, 29 mm.; of hind femora, 16 mm.

The only specimen, the type, comes from the Cayari Island in the Uassa Swamp. It was taken in May, 1918, by S. M. Klages. C. M. Acc. No. 6177.

Genus OPSOMALA Serville.

Opsomala BURMEISTER, Handb. Ent., II, p. 610 (1838); SERVILLE, Ins. Orth., III, p. 419 (1910). For additional synonymy see Kirby, *l. c.*

This genus is separated from among the other Leptysmine locusts by the plain last ventral segment of the abdomen of the males. Otherwise the members are very similar to those assigned to the genus *Stenacris* of Walker. Kirby lists three species definitely, and three doubtfully, as belonging to the genus. In the case of *interior* Bruner, he is mistaken, as it is definitely a *Stenacris*. Probably in the case

of *stæli*, although it has the external margin of the hind tibiæ armed with nine or ten spines, he may be correct. But the inclusion of *nasica* and *falconia* is undoubtedly in error. We now find before us a new species, which must be assigned to the genus. We then still have four species, which may be separated by the subjoined synoptical key.

SYNOPSIS OF THE SPECIES OF OPSOMALA.

A. Antennæ decidedly ensiform. Hind tibiæ provided with 9–10 spines externally. Tegmina narrowly acuminate. Wings rather strongly infuscated, or at least with obscure veins [Southwestern Brazil]. . . *stæli* Bruner.

AA. Antennæ only faintly ensiform, or subensiform. Hind tibiæ seven- to nine-spined externally. Tegmina subacuminate. Wings not greatly infuscated, nor with especially dark veins.

B. Hind tibiæ and their tarsi wholly pale coral-red. The abdomen above testaceous.

C. Insect larger and more robust (♂, 34–35, ♀, 40 mm.). General color pale yellowish grass-green. [Brazil, Paraguay, and Bolivia.] . . . . . *coccineipes* Bruner.

CC. Insect smaller and rather slender (♂, 29, ♀, 36 mm.). General color pale bluish green. (Cayenne.) . . . . . *intermedia* sp. nov.

BB. Hind tibiæ with a large green space basally. The abdomen above blood-red (Brazil) . . . . . *viridis* Serville.

88. **Opsomala coccineipes** (Bruner).

Arnilia coccineipes BRUNER, Proc. U. S. Nat. Mus., XXX, p. 659 (1906); IB., Biol. Cent.-Amer., Orth., II, p. 254 (1908).

A single female of this locust is at hand from the Province del Sara, Bolivia. It was taken in the month of October, 1913, by Steinbach. C. M. Acc. No. 5058.

Judging from the structure of the hind tibiæ and femora, and from personal experience while collecting in Paraguay, I should say that this insect is a denizen of open meadows and away from water. Possibly the same characteristics may be true of all of the species of this genus.

89. **Opsomala intermedia** sp. nov.

A rather slender species, of a pale blue-green color, apparently intermediate between the species *coccineipes* and *viridis*, as indicated by the Synoptic Key given above. Head about as wide as the anterior edge of the pronotum, the front rather strongly oblique, the fastigium a little wider at base than long, its sides a little rounded (♂), or nearly

straight (♀), and a little elevated into bounding carinæ. Vertex in the male about as wide, in the female one-half wider than the diameter of the basal antennal joint. Antennæ sublinear of moderate length, and in nowise hastate, the basal joints alone only faintly depressed.

Pronotum subcylindrical, very gently and broadly strangulate, finely rugulose and punctate, the transverse sulci fine and little impressed; anterior edge little, but widely and roundly, emarginate at middle; the hind margin of disc subangulate. Tegmina narrow, extending about one-fifth of their length beyond the tip of the abdomen in both sexes, subacuminate. Hind femora normal, somewhat shorter than the abdomen; the hind tibiæ slender, but with the lateral margins acute and a little prominent apically, armed externally with from seven to eight spines. Tip of the male abdomen subacuminate, the last ventral segment simple, about one-half longer than its basal width, the outer half finger-like and directed backwards and upwards, its extreme apex blunt. Supra-anal plate small, its apical half narrowed and extending beyond the strongly curved pale cerci; the edges of the median sulcus and apex of the last abdominal segment on the upper side marked with black. Prosternal spine rather elongate, clubbed, and blunt at its apex and somewhat directed to the rear. Anterior and median legs short, small.

General color of head, pronotum, pleura, and tegmina pale bluish green; the legs and underside paler, inclining to dirty white or testaceous; the hind tibiæ and tarsi coral-red. Antennæ testaceo-ferruginous, in the male infuscated apically. Hind femora internally pale piceous, owing to the shining through of the dried muscular tissue. Abdomen pallid, uncolored above.

Length of body, ♂, 29 mm., ♀, 36 mm.; of pronotum, ♂, 4.8 mm., ♀, 6.5 mm.; of tegmina, ♂, 25 mm., ♀, 33 mm.; of hind femora, ♂, 13.5 mm., ♀, 16 mm.

Two males and a female of this new species from Cayenne. They were taken in February and March, 1917, by S. M. Klages. C. M. Acc. No. 5873. One of the males is made the type of the species.

Genus STENACRIS Walker.

Stenacris WALKER, Cat. Derm. Salt. Brit. Mus., IV, p. 651 (1870); KIRBY, Syn. Cat. Orth., III, p. 413 (1910); BRUNER, Annals Carnegie Mus., VIII, p. 479 (1913).

Armilia STÅL, Recens. Orth., I, pp. 42, 85 (1873).

As indicated on page 479 of volume VIII of these ANNALS, the insects which comprise the genus *Stenacris* are quite similar in their general appearance to those referred above to *Opsomala* Serville. In the representatives of *Stenacris* "the last ventral segment of the male abdomen is quite complex in structure, and varies very distinctly among the different species," while in *Opsomala* it varies but little. About a dozen species have already been described and now four more are recognized and herewith described.

90. **Stenacris vitreipennis** (Marschall)?

Gryllus vitreipennis MARSCHALL, Ann. Wien. Mus., I, pp. 214–215, pl. 18, fig. 6 (1836).

Stenacris chlorizans WALKER, Cat. Dermapt. Salt. Brit. Mus., IV, pp. 652, 653 (1870); KIRBY, *l. c.*, p. 413 (1910). For fuller synonymy see the last reference.

There are two females of a locust belonging to this genus at hand. They come from the Isle of Pines, where they were collected at Nueva Gerona in June, 1912. They are placed here, because there can be but little doubt that they are the same species as the insect well-known from the southeastern portions of the United States.

91. **Stenacris cylindrodes** (Stål).

Opsomala cylindrodes STÅL, Kong. Svensk. Freg. Eugen. Resa., Ins., p. 325 (1860).

Arnilia cylindrodes STÅL, Recens. Orth., I, p. 85 (1873).

Stenacris cylindrodes REHN, Proc. U. S. Nat. Mus., XXXVI, pp. 135, 136 (1909).

The present species does not seem to be represented in the material now at hand, although it has been reported from the adjoining regions of Brazil and Paraguay. Judging from the experience of the present writer *cylindrodes* is confined chiefly to the coastal regions of Brazil, with Rio Janeiro as the type-locality. The specimens of this species heretofore reported from Paraguayan and interior Brazilian localities may have been one or the other of the two following, or even a distinct and allied form.

92. **Stenacris interior** (Bruner).

Arnilia interior BRUNER, Biol. Cent.-Amer., Orth., II, p. 254 (1908).

Opsomala interior KIRBY, Syn. Cat. Orth., III, p. 419 (1910); BRUNER, Ann. Carnegie Mus., VIII, pp. 81 (1911), 479 (1913).

There are three males in the collections now receiving attention which are apparently the same as the insect to which this name was given, but as the type is not at hand, I hesitate to give a more com-

plete description of the species now. Two of them come from the Upper Mamoré River in the Department of Santa Cruz, Bolivia, where they were taken in December, 1913, at an altitude of 200 meters above sea-level. The other specimen was collected in November, at Quatro-Ojos in the same province at an elevation of 300 meters. All three of them were obtained by Haseman. The last mentioned specimen belongs to C. M. Acc. No. 5059, and the former two to C. M. Acc. No. 5061.

All three specimens show a decided rufous tinge on the dorsum of the pronotum, as did the type-material, as now recalled by me.

93. **Stenacris forficulata** sp. nov.

Two males belonging to this genus and coming from Quatro-Ojos, in the Department of Santa Cruz, Bolivia, are separated from the preceding by the structure or the male genitalia. They belong in the section of the genus containing *S. columbæ* and *S. fissicauda* Bruner, as characterized in the Biologia Centrali-Americana, Orth., II, pp. 225 and 258. When compared with these two species *forficulata* approaches *fissicauda* most closely in size and in the structure of the apical segment of the male abdomen. The general color of the insect is pale grass-green, with little or no indication of a longitudinal pallid lateral line on the sides on the head, pronotum, and thorax, as is so frequently seen in several of the species of the genus. The wings, although not spread, appear to be infuscated and to have a slightly bluish tinge. The dorsum of the abdomen, however, is a little infuscated, and the hind tarsi are tinged with pinkish red.

Length of body, ♂, 26 mm.; of pronotum, 5.5 mm.; of tegmina, 22 mm.; of hind femora, 13 mm. The female which is also assigned to this species is 30 mm. in length, with the tegmina 27 mm. long.

Habitat: Quatro-Ojos, Department of Santa Cruz, Bolivia, at an altitude of 300 meters above sea-level. Taken in November, 1913, by J. Steinbach. C. M. Acc. No. 5059.

94. **Stenacris** sp.(?)

There are at hand two females of what appears to be still another species of *Stenacris*. They were taken on Uassa Island in the Uassa Swamp during the month of June, 1918, by S. M. Klages. C. M. Acc. No. 6176.

These individuals have the general aspect of some of the females of the Cayenne specimens which I am describing in the present paper as *Stenacris cayennensis*. I observe, however, that these specimens from the Uassa swamp have paler wings than do those coming from Cayenne.

95. **Stenacris cayennensis** sp. nov.

A comparatively small, slender insect, related to the species *minor* and *marschalli* of Bruner, as described in the Biologia Centrali-Americana, Orthoptera, Vol. II, pp. 256 and 257, but closer to the latter than the former. In the present characterization comparisons therefore will be made with the descriptions of those species.

General color somewhat variable, owing to the variation in the amount of dusky markings present in different individuals. Head moderately large, a little wider than the anterior edge of the pronotum; eyes large and prominent, separated above by a space very little wider (♂) or fully twice (♀) that of the diameter of the basal antennal joint; the fastigium depressed, horizontal, a little shorter than its basal width, the width broadly convex, and showing only a faint indication of sulcation near its anterior edge, the lateral edges very gently bowed and faintly carinated, this most apparent in the males. Front rather strongly retreating, viewed laterally gently bowed inwards at middle, owing to the prominence of the frontal costa between the antennæ, the latter moderately well defined, the lateral walls heavy and bisinuate, giving the costa two wider portions, viz., one above between the antennæ, and the other at the median ocellus, continuous to the clypeus, roundly and deeply sulcate throughout; lateral or facial carinæ slender, straight, divergent, extending from the lateral ocelli to the outer facial angles at the base of the clypeus. Antennæ of moderate length, nearly (♀) or quite (♂) reaching the posterior margin of the pronotum, almost linear, only the three or four basal joints slightly depressed. Pronotum subcylindrical, considerably longer than wide, the middle a little arcuate or strangulate by having the base and apex slightly wider than at middle, the surface finely punctulate, the transverse furrows well marked; front and hind borders broadly rounded. Tegmina fully developed, extending beyond the tip of the abdomen in both sexes, their apex subacuminate. Hind femora normal, not reaching the apex of the abdomen in either sex; the tibiæ not markedly expanded

apically, six- or seven-spined externally, nine-spined internally; anterior and middle legs short, but fairly robust. Last ventral segment of the male abdomen with the main portion a little longer than the basal width, its outer two-thirds with the sides parallel, and ending on either side in short, prominent, rounded lobes; the median portion fully as long as the basal, directed upwards, and with its apical half slender and directed upward and obliquely, as well as arcuately, to the rear. Cerci rather large, their apical portion transverse, truncated, and with the apex infuscated. Valves of the ovipositor short, their margins six- or seven-toothed, the teeth strong. Prosternal spine large, robust, the apex evenly rounded and directed gently to the rear.

General color various shades of pale green, white, and testaceous, varied with piceous, ferruginous, brown, and black. These hues are arranged in longitudinal streaks and patches as follows: occiput, cheeks back of the eyes, disc, and upper part of the sides of the pronotum, meso- and metapleura, and the tegmina, prevailingly some shade of green; the occiput marked with two longitudinal divergent white stripes; the cheeks below, the lower third of the sides of the pronotum and the pleura longitudinally white; also, in the type, a white line running along each side of the disc of the pronotum; above this white lateral line is one of greater or less intensity of piceous, olivaceous, or ferruginous. The disc of the pronotum is usually ferruginous, vinaceous, or even brown, the abdomen above strongly infuscated, below pallid, the legs testaceous, or greenish straminiceous. Antennæ ferruginous, a little infuscated internally at base and apically. Posterior edge of the last abdominal segment above and the carinæ of the supra-anal plate black; wings infuscated. In some specimens there is a somewhat general dark tinting of the whole insect both above and below, when the front, pectus at middle, and underside of the abdomen are vinaceous brown gradually shading off to testaceous and green, or to olivaceous. In some specimens the white lines are quite noticeably tinted with green.

Length of body, ♂, 24 mm., ♀, 31 mm.; of pronotum, ♂, 4 mm., ♀, 4.5 mm.; of tegmina, ♂, 20 mm., ♀, 26 mm.; of hind femora, ♂, 12 mm., ♀, 14.5 mm.; of antennæ, ♂, 8.5 mm., ♀, 7.75 mm.

Habitat: This insect is represented by three males and three females from Cayenne, French Guiana, collected in February and March, 1917, by S. M. Klages. They belong to C. M. Acc. Nos. 5873 and 5897. The male type belongs to the latter accession, while the female

type is from the former. There is also a male at hand from Mana River where it was collected in May. C. M. Acc. No. 6008.

96. **Stenacris megacephala** sp. nov.

This insect is characterized chiefly by its excessively large and smooth head, which is considerably wider than the anterior edge of the strangulate pronotum, which is likewise rather robust; also by the widely lamellate lateral edges of the hind tibiæ.

Fastigium of the vertex depressed, somewhat declivant in front, the base almost twice as wide as the median length, separated from the vertex by a rather well-defined transverse furrow, the disc full and showing only slight indication of a longitudinal sulcus or irregularities, the sides nearly straight, the anterior angle obtuse. Vertex between the eyes fully twice the width of the basal antennal joint. Front somewhat oblique, but not so greatly as in the other species of the genus. The frontal costa rather broad and roundly sulcate, viewed laterally straight, its lateral walls not greatly sinuose, continuous to the base of the clypeus. Antennæ sublinear, scarcely at all enlarged at their base, of normal length, not reaching much beyond the last transverse sulcus of the pronotum. The latter faintly and minutely punctulate, smooth, narrowest at the hind sulcus, which is narrow, but profound, the other sulci also deeply but narrowly impressed. Tegmina somewhat acuminate, extending but little beyond the tip of the abdomen. Valves of the ovipositor rather short, the teeth small and weak, the apex of the lower pair scarcely hooked. Prosternal spine moderately large, long and club-shaped, directed somewhat caudad, its apex blunt and almost touching the anterior margin of the mesosternum.

General color of front, head above, pronotum and tegmina olivaceous, lower edges of the cheeks, sides of the pronotum and meso- and metapleura rather widely streaked longitudinally with ivory-white, this in turn bordered above by a fuscous or dull piceous band, which gradually merges above into the general olive hue. Anterior and middle legs greenish, fading basally to testaceous, the hind femora olivaceous yellow, or greenish straw-color; hind tibiæ olivaceous basally, becoming pale vinaceous apically, the hind tarsi coral-red. Antennæ ferruginous, apically infuscated.

Length of body, ♀, 36 mm.; of head in front of the pronotum 5.5

mm.; of pronotum 6 mm.; of tegmina, 27 mm.; of hind femora, 15.5 mm.

Habitat: The type, a female, comes from Uassa Island, Uassa Swamp, where it was collected in June, 1918, by S. M. Klages. C. M. Acc. No. 6167. There is also a second female at hand, bearing the label "Oucatopi Island, S. M. Klages, C. M. Acc. 6178." It was likewise taken in June, and agrees in all respects with the type.

Genus TUCAYACA gen. nov.

Related to *Stenacris*, but differing from that genus in having the body of the males noticeably more robust, the face more strongly receding or oblique, the antennæ decidedly ensiform, and the hind legs comparatively heavier and longer. When compared with the various species of *Stenacris*, the type of the present genus, *T. aquatica*, is seen to have the last ventral segment of the abdomen of the male more elongate, tapering, and simple. In the table or key for separating the tropical American genera of *Leptysmæ* and allies (ANNALS, VIII, pp. 69–71) *Tucayaca* runs to *cc.* under *A*. In order to insert it we would then add the following:

d. Fastigium about as long as wide, its sides convergent from the base, and but little bowed, the lateral edges little, if at all, carinated. Occiput somewhat arched, the head shorter than the pronotum. Antennæ with the basal joints but little dilated. Apex of the male abdomen with the last ventral segment not greatly elongate, often quite elaborated with tubercles, spines, or other appendages. . . . . *Stenacris* Walker.

dd. Fastigium of the vertex a little longer than wide, the sides on its basal third or half parallel, beyond this point bowed, the lateral edges strongly carinated. Occiput straight, the head as long as the pronotum. Antennæ with the basal joints plainly dilated, giving to these members a subensiform appearance. Apex of abdomen of male with the last ventral segment rather elongate, not complicated with appendages, but gradually tapering, and directed backward and upward. . . . . *Tucayaca* gen. nov.

97. **Tucayaca aquatica** sp. nov.

General color wood-brown above, testaceous below. Sides of the head, pronotum, and pleura broadly banded with piceous, bordered below by a dirty white line. Eyes fairly prominent, nearly twice as long as wide. Vertex somewhat depressed, not quite as wide as the diameter of joint two of the antennæ, the latter about one-third longer than the head and the pronotum combined; the fastigium with its

disc rounded or convex, and bearing a longitudinal sulcus throughout; the frontal costa prominent, a little ampliated above the antennæ, profoundly sulcate throughout, and continuous to the clypeus. Mesosternal lobes with their inner edges touching for a considerable portion of their length. Prosternal spine of moderate robustness, cylindrical, straight, its apex blunt. Tegmina acuminate, extending about one-fifth of their length beyond the tip of the abdomen. Abdomen gently tapering, the supra-anal plate scutellate, its apical third narrower, triangular, flat, and with its apex rounded. Cerci of moderate size, strongly curved upwards, the apex black. Hind tibiæ strongly dilated, their lateral edges acute, seven- to eight-spined externally.

Length of body, ♂, 27 mm.; of pronotum, 6 mm.; of tegmina, 23 mm.; of hind femora, 14.5 mm.

Habitat: Upper Mamoré River in the Department of Santa Cruz, Bolivia, December, 1913. The type and a second male were collected at an altitude of 200 meters above sea-level by J. Steinbach. C. M. Acc. No. 5061.

98. **Tucayaca normalis** sp. nov.

Very similar in general appearance to the preceding, but differing from it in its slightly larger size, the somewhat longer and differently shaped fastigium of the vertex, and in the broader and apically rounded last ventral segment of the male abdomen.

Head large, elongate, somewhat ascending, the front strongly retreating, viewed in profile nearly straight; the fastigium of the vertex moderately large, about two-thirds the length of the longest diameter of the eyes; its sides parallel at the base for a little less than one-half of its length, beyond this nearly straight and somewhat convergent to the narrowly rounded apex, the lateral edges heavily carinated; the disc viewed from the side strongly and arcuately convex, its middle longitudinally, evenly, and roundly sulcate. Frontal costa prominent, with the lateral walls bowed, and forming a rather wide ovate loop above between the antennæ, from this point very gently and evenly divergent below, reaching the clypeus, profoundly sulcate throughout. Antennæ rather heavy, slightly ensiform, somewhat longer than the head and pronotum combined, the basal joint rather robust, scarcely as long as wide, concolorous. Vertex as wide as the basal antennal joint, depressed in front, separated from the fastigium

by a transverse sulcus or depression. Pronotum subcylindrical, a little narrower at its middle than in front and behind; the surface minutely and closely punctulate; the transverse sulci narrow, not deeply impressed, but plainly visible; the median carina slender, but apparent throughout; both the anterior and posterior margins of the disc broadly rounded. Tegmina of moderate width, tapering only on their apical fifth, acuminate. Legs long and robust, the hind femora not quite reaching the tip of the abdomen of the male, their genicular area rather small, the lateral lobes acuminate, but not spined. Hind tibiæ moderately expanded apically, where the lateral carinæ are sharp and more or less lamellate, as well as closely fringed with hairs; provided internally with eleven and externally with ten spines. Last ventral segment of the abdomen of the male about twice as long as broad at the base, a little tapering, and with the apical portion spatulate, the apex slightly and roundly emarginate at middle. Cerci strongly curved upwards, the apical half transverse and obliquely docked from the inner edge. Supra-anal plate very similar to the general type for the group, its carinæ and the edge of the preceding segment marked with black. Prosternal spine rather long and robust, directed strongly posteriorly or caudad.

General color above testaceo-ferruginous, under side and legs testaceous, possibly greenish in life, the sides marked from the lower edge of the eyes to the base of the hind femora with a prominent white stripe bordered above by one of piceous. Antennæ ferruginous, their inner edge basally infuscated.

Length of body, ♂, 27 mm.; of pronotum, 4.5 mm.; of tegmina, 23.5 mm.; of hind femora, 14 mm.

Habitat: The type, and only representative of the species at hand, is from Oucatopi Island, where it was taken in June, 1918, by S. M. Klages. C. M. Acc. No. 6178.

Genus INUSIA Giglio-Tos.

Inusia GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XII, no. 302, p. 30 (1897); BRUNER, Journ. N. Y. Ent. Soc., XIV, p. 151 (1906); IB., Biol. Cent.-Amer., Orth., II, pp. 212, 259 (1907–8); IB., Ann. Carnegie Mus., VIII, p. 70 (1911).

99. **Inusia chipmani** Bruner.

Inusia chipmani BRUNER, Journ. N. Y. Ent. Soc., XIV, p. 154 (1906); IB., Biol. Cent.-Amer., Orth., II, pp. 259, 260 (1908); KIRBY, Syn. Cat. Orth., III, p. 414 (1910).

The present species is represented by three males and three females. They come from Cayenne, French Guiana, where they were collected from January to March, 1917. C. M. Acc. Nos. 5817 and 5873.

100. **Inusia pallida** Bruner?

Inusia pallida BRUNER, Proc. U. S. Nat. Mus., XXX, p. 660 (1906); IB., Biol. Cent.-Amer., Orth., II, p. 259 (1908).

A single male specimen of the genus *Inusia* coming from the Province del Sara, Bolivia, is referred here with some doubt, since its coloration differs considerably from that of the type. But, as this one is a male, and the type was a female, the difference in color might be accounted for by the difference in sex. It was collected by J. Steinbach in December, 1912, at an altitude of 350 meters above sea-level. C. M. Acc. No. 5058.

Genus STENOPOLA Stål.

Stenopola STÅL, Recens. Orth., I, pp. 42, 83 (1873); BRUNER, Ann. Carnegie Mus., VII, p. 70 (1911); KIRBY, Syn. Cat. Orth., III, p. 415 (1910).

101. **Stenopola dorsalis** (Thunberg)?

Truxalis dorsata THUNBERG, Nova. Acta Upsal, IX, p. 80 (1827).
Stenopola dorsalis STÅL, Recens. Orth., I, p. 83 (1873); KIRBY, *l. c.*, p. 415 (1910).
Opomala femoralis WALKER, Cat. Derm. Salt. Brit. Mus., III, p. 509 (1870).

Three males of a small locust coming from the Mana River, French Guiana, are placed here. They were collected in May, 1917, by Klages C. M. Acc. No. 6008.

Genus OXYBLEPTA Stål.

Oxyblepta STÅL, Recens. Orth., I, p. 84 (1873).
Stenopola STÅL, Bihang. Svensk. Akad. Handl., V (4), p. 39 (1878); BRUNER, 2nd Rep. Locust Comm. B. Aires, pp. 54, 66 (1900); GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XIII, no. 311, p. 45 (1898), etc.

The representatives of the present genus occur in tropical America from Panama to northern Argentina. Like the species of the next genus, they are of moderate size, and not very different in color and structure. As in some other genera of the group Leptysmæ, there is considerable diversity of opinion concerning the number and limitation of species.

The present collection contains representatives of apparently three distinct forms.

102. **Oxyblepta puncticeps** Stål.

Opsomala puncticeps STÅL, Eugenies Resa, Orth., p. 325, no. 68 (1860).

Stenopola (Oxyblepta) puncticeps STÅL, Recens. Orth., I, p. 84 (1873); ? GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 31 (1894); BRUNER, Proc. U. S. Nat. Mus., XXX, p. 661 (1906).

Two females from the Province del Sara in Bolivia are referred here. One of them was taken in November, 1911, and the other either in November or December, 1912. They were collected by J. Steinbach at an elevation of 350 meters above sea-level, and agree in color and general appearance with a specimen in the present writer's possession taken in Paraguay by W. T. Foster. There are also two males and two females at hand, which bear the label "Rio Japacani, E. Bolivia, Feb. 1915, J. Steinbach, Acc. 5573." These I also refer here, although they are rather too small, if Stål's measurements are correct.

103. **Oxyblepta minor** sp. nov.

Very similar to the preceding, but much slenderer and smaller, and with shorter tegmina and wings.

Head rather large, wider than the front edge of the pronotum, the eyes very prominent, castaneous, and longitudinally streaked with testaceous, the vertex very narrow, not much wider than one-half the diameter of the rather heavy antennæ near their base. Fastigium of the vertex acuminate, of moderate size, the frontal costa prominent above between the base of the antennæ, almost obliterated below. Antennæ robust, in the male fully as long as, in the female a little shorter than, the hind femora. Front, occiput, disc of the pronotum, and the pleura strongly and closely punctulate, the cheeks more sparsely so. Tegmina as long as the abdomen, their apex somewhat acuminate. Hind femora moderately robust, in the female not quite reaching, in the male passing the tip of the abdomen a trifle.

General color as in *puncticeps*. The pale line on the lower portion of the lateral lobes of the pronotum and pleura beautifully maculate with gamboge-yellow. Geniculæ of the hind femora with the lunules ferruginous.

Length of body, ♂, 18.5 mm., ♀, 22 mm.; of pronotum, ♂, 3.6 mm., ♀, 4.2 mm.; of tegmina, ♂, 13 mm., ♀, 17 mm.; of hind femora, ♂, 10 mm., ♀, 12 mm.

Habitat: One pair *in coitu*, taken in December, 1913, at Las Juntas,

Department of Santa Cruz, Bolivia, by J. Steinbach, at an elevation of 250 meters above sea-level. C. M. Acc. No. 5060.

104. **Oxyblepta bohlsii** (Giglio-Tos).

Stenopola bohlsii GIGLIO-TOS, Boll. Zoöl. Jahrb., Syst., VIII, p. 813 (1895); BRUNER, Proc. U. S. Nat. Mus., XXX, p. 661 (1906).

Three females of this species are at hand. They come from the Province del Sara, Bolivia, where they were collected at 350 meters above sea-level by J. Steinbach. C. M. Acc. No. 5058.

The present species differs from the two preceding in having the longitudinal lateral pallid lines composed of large, smooth, elevated maculæ, instead of being continuous. The geniculæ of the hind femora are bright ferruginous.

Genus HENIA Giglio-Tos.

Henia GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XIII, no. 311, pp. 45, 55 (1898); BRUNER, Biol. Cent.-Amer., Orth., II, p. 261 (1908); IB., Ann. Carnegie Mus., VIII, p. 70 (1911).

This genus is confined to South America, so far as our present knowledge reveals. It contains insects of medium size, the known species ranging in lengths from 15 to 21 mm. in the males, and 21 to 26.5 mm. in the females. Two species have been heretofore described and the present collection contains what seem to be three additional forms. All of the species are found very close to, or south of, the equator, and in the interior. They may be separated by the annexed key.

SYNOPSIS OF THE SPECIES OF HENIA.

A. Form of insect rather slender.

b. Smaller (♂, 15–16 mm., ♀, 21–23 mm.).

c. Antennæ shorter (9–11 mm.).

d. Antennæ less elongate, pale red (♀, 8.75–9 mm.). *frenata* Marschall.

dd. Antennæ more elongate, black (♂, and ♀, 10–11 mm.). *suinama* sp. nov.

cc. Antennæ longer (13–15 mm.).

d. Length of body (♀, 21 mm.). Dorsum of pronotum uniformly olive-yellow. Hind femora gamboge-yellow. Abdomen and venter pale cinnamon. . . . . *boliviana* Rehn.

dd. Length of body (♂, 19, ♀, 26.5 mm.). Dorsum of pronotum with the disc fusco-olivaceous, bordered at the sides by

prominent gamboge-yellow lines, in continuation of the pale dorsal angles of the tegmina. Hind femora pale grass-green. Abdomen and venter flavo-testaceous. . . . *steinbachi* sp. nov.

AA. Form of insect rather robust. General color of the body and limbs pale brownish yellow. Dorsum of the head, pronotum, and tegmina infuscated and bordered on each side by testaceous. . . . . *testacea* sp. nov.

105. **Henia surinama** sp. nov.

Very similar to, and possibly the same as Marchall's *Gryllus frenatus*, from which our material varies chiefly in the slightly larger size, more acute tegmina, and somewhat longer and much darker antennæ. The measurements are as follows:

Length of antennæ, ♂ and ♀, 10–11 mm.; of body, ♂, 17 mm., ♀, 23 mm., of pronotum, ♂, 3.1 mm., ♀, 4 mm.; of tegmina, ♂, 15 mm., ♀, 18 mm.; of hind femora, ♂, 10 mm., ♀, 12.5 mm.

Habitat: Three males and two females are before me as I write. They all come from Cayenne, French Guiana, where they were collected in February and March, 1917. I have designated a male as the type. C. M. Acc. No. 5873.

106. **Henia steinbachi** sp. nov.

Related to *H. boliviana* Rehn, but very noticeably larger and darker colored, on account of the obscure occiput, disc of the pronotum, and dorsal field of the tegmina. Otherwise very little different from that species. In fact, aside from comparative size and color variation, the various species of the genus are very similar.

Length of body, ♂, 19 mm., ♀, 26.5 mm.; of pronotum, ♂, 4 mm., ♀, 5.15 mm.; of tegmina, ♂, 17 mm., ♀, 21 mm.; of hind femora, ♂, 12 mm., ♀, 15 mm.

Habitat: Two males and one female come from Las Juntas and a single male from Quatro-Ojos, in the Department of Santa Cruz, Bolivia. The last mentioned male was taken in November at an elevation of 300 meters, and the former three specimens were collected in December at 250 meters above sea-level. There are also two females, taken at Buena Vista, E. Bolivia, the latter belong to C. M. Acc. No. 5573. All of them were taken by J. Steinbach. The type, a female, belongs to C. M. Acc. No. 5060.

107. **Henia testacea** sp. nov.

As shown by the synoptical key the present species differs from the others in its more robust form and prevailing bruneo-testaceous color.

Length of body, ♂, 21 mm.; of pronotum, 4.1 mm.; of tegmina, 17.5 mm.; of hind femora, 13 mm.

Habitat: A single male, the type, comes from the Province del Sara, Bolivia, where it was collected by J. Steinbach during the period of November-December, 1912, at an altitude of 350 meters above sea-level. C. M. Acc. No. 5058.

Genus CORNOPS Scudder.

Cornops SCUDDER, Proc. Bost. Soc. Nat. Hist., XVII, p. 276 (1875); GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 31 (1894), XIII, no. 311, p. 45 (1898); BRUNER, Journ. N. Y. Ent. Soc., XIV, p. 152 (1906); IB., Proc. U. S. Nat. Mus., XXX, p. 662 (1906), etc.

108. **Cornops bivittatum** Scudder.

Cornops bivittatum SCUDDER, Proc. Bost. Soc. Nat. Hist., XVII, p. 276 (1875); GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 32 (1894).

Two females and one male from the Province del Sara, Bolivia, are referred to Scudder's species *bivittatum*. They were collected by J. Steinbach at an altitude of 350 meters. C. M. Acc. No. 5058. There is another female from the Rio Japacani, eastern Bolivia, taken by the same collector in Feb., 1915. C. M. Acc. No. 5573.

109. **Cornops longipenne** De Geer.

Acrydium longipenne DE GEER, Mém. Ins., III, p. 501, no. 18, pl. 42, fig. 9 (1773).
? Paracornops longipenne BRUNER, Proc. U. S. Nat. Mus., XXX, p. 662 (1906).
Cornops longipenne REHN, Trans. Am. Ent. Soc., XLII, pp. 286, 287—in discussion of synonymy, Sept. 23, 1916; IB., *l. c.*, XLIV, p. 204 (1918).

There are three males and three females of this insect at hand. They all come from Cayenne, French Guiana, where they were taken in April, 1917. C. M. Acc. No. 5897.

Coming from a locality so comparatively near to and similar to that, from which *Acrydium longipenne* De Geer, was derived, there can scarcely be room for doubt as to their identity. The specimens seem to agree in every respect with the original description, as well as with most of the characters mentioned by Rehn in his discussion referred to above, and based upon almost certainly authentic material.

110. **Cornops insulare** Bruner.

Cornops insularis BRUNER, Biol. Cent.-Amer., Orth., II, p. 262 (1908).
Cornops bivittatum BRUNER (*nec* Scudder), Journ. N. Y. Ent. Soc., XIV, p. 154 (1906).

Four males and two females of this beautiful insect, were collected at Cayenne, in February, March, and April, 1917. C. M. Acc. Nos. 5873 and 5897.

III. **Cornops pelagicum** sp. nov.

There is a female of what appears to be still an additional species of *Cornops* among the material now being studied. It was taken on Oucatopi Island by S. M. Klages in June, 1918. The description follows:

Medium in size; rather robust; the tegmina and the wings decidedly shorter than in such species as *longipenne*, *ignotum*, *insulare*, and *paraguayense*, with all of which it agrees fairly well in size. Head short, the front not very oblique, viewed laterally a little rounded, strongly and closely punctured; fastigium of the vertex short and wide, almost twice as wide at the base as the length, the lateral edges straight, the apex blunt, its disc depressed and provided with a wide longitudinal sulcus; antennæ slender, filiform, about reaching the apex of the pronotum; the frontal costa fairly prominent, widest above the base of the antennæ and evenly and gradually narrowing below where its sides meet and terminate just before reaching the clypeus, profoundly sulcate from a point just above the antennæ. Vertex about one and three-fourths as wide as the diameter of the rather large subconical basal antennal joints, but little depressed; occiput short, gently rounded. Pronotum strongly punctate, subcylindrical, a little widest behind, the hind margin broadly angulate, the median carina fairly prominent back of the last transverse sulcus, but diminishing cephalad. Tegmina very little longer than the abdomen, their apex rounded. Hind femora robust at base, but slender on the apical half, their genicular lobes elongate and finely acuminate, almost spiniform; the hind tibiæ strongly expanded apically, and with the fringe of hairs on their inner margin quite dense and noticeable, the spines large and tipped on outer half or third with deep black. Prosternal spine erect, a little transverse, elongate, and broadly rounded at its apex. Valves of the ovipositor short, broad, the outer margin armed with about a dozen small teeth, the inner margin provided near its middle with several, while the bulging disc is thickly studded with them, giving it a sharply granular appearance.

General color olive-green above, becoming grass-green on the tegmina. Paler beneath, where the prevailing hue is flavous. Sides of

the head, upper half of the sides of the pronotum and pleuræ heavily longitudinally striped with black, the upper edge of which gradually merges with the dorsal color. Genicular area of the hind femora and the base of the tibiæ scarcely marked or even tinged with black, fuscous, or ferruginous. Antennæ dark olive-green.

Length of body, ♀, 27 mm.; of pronotum, 5 mm.; of tegmina, 21 mm.; of hind femora, 14.5 mm.; of antennæ 8.5 mm.

The type is unique, and belongs to C. M. Acc. No. 6178.

Genus TETRATÆNIA Stål.

Tetratænia STÅL, Recens. Orth., I, pp. 34, 53 (1873); KIRBY, Syn. Cat. Orth., III, p. 418 (1910). For further bibliography see Kirby, *l. c.*

The genus *Tetratænia* is composed of several species of medium-sized, highly colored locusts, which, judging from the greatly lamellate edges of the hind tibiæ, live among aquatic plants. At least a half dozen species are known.

112. **Tetratænia phila** Rehn.

Tetratænia phila REHN, Proc. Acad. Nat. Sci. Philad., May, 1918, pp. 172–175, Pl. I, figs. 25, 27.

The specimens were at first doubtfully determined as *Gryllus surinamus* Linnæus, but, when compared with the description of Rehn's new species *T. phila*, their identity with it was at once detected. There are four males and two females. They are labelled as follows: one male and a female, "Cayenne, Mch., C. M. Acc. 5897," a male and female "Oucatopi Island, S. M. Klages, June, 1918, Acc. 6178"; one male (imperfect) "Cayari Island, Uassa Swamp, May, 1918, Acc. 6177"; and a male, Benevides, Pará, Brazil, Oct. 1918, also taken by Klages, C. M. Acc. 6174.

These specimens are very uniform in both size and color.

113. **Tetratænia australis** sp. nov.

There is a single mutilated male of a species of *Tetratænia* from the Province del Sara, Bolivia, collected by J. Steinbach during the period March–April, 1913, at an altitude of about 350 meters above sea-level. Although the mutilation consists in the absence of both hind legs, it seems worth while to briefly characterize it under the above name, since it seems to come from the most southern locality from which a representative of the genus is recorded.

In color this specimen approaches *surinama* and in size is slightly larger than the largest specimen of *surinama* as recorded by Rehn (Proc. Acad. Nat. Sci. Philad., May, 1918, p. 172) where he mentions the variability of the species.

Head large, the occiput short, smooth, bullate; vertex between the eyes a very little greater than the diameter of the basal antennal joint; the fastigium of the vertex short, depressed, broadly sulcate at middle, the sulcation gradually, roundly, and faintly merging into that of the frontal costa, which latter is rather prominent above between the bases of the antennæ, but quickly lowers at the ocellus and below, continuous but inconspicuous to the clypeus. Antennæ filiform, quite coarse, about one-half longer than the head and pronotum combined. Pronotum glabrous, but quite closely punctulate and rugose, save at its sides between the hind sulcus and the anterior margin, where the surface is almost smooth; anterior margin a little advanced upon the occiput, the middle angulately emarginate, the hind border broadly angulate, but with the apex triangularly emarginate, the transverse sulci profound; the median carina rather coarse, cut by all three sulci. Tegmina of moderate width, the costal margin somewhat broadly and shallowly lobate near the base, reaching well beyond the tip of the abdomen, apex rounded. Apex of the abdomen slender, the last ventral segment and subgenital plate pale, smooth, and together forming a differentiated area, appearing quite different from the other ventral portion and directed obliquely upward, the sub-genital plate on its outer half compressed to about one-third of its basal width, the apex narrowly prow-shaped, entire; cerci elongate, abruptly bent both upwards and inwards, the slender finger tapering but little, so that the two by bowing inwards touch their tips above the apex of the supra-anal plate, which latter is formed somewhat like that in other members of the genus, as are also the lobes of the preceding segment in advance of the bases of the cerci. Prosternal spine rather long and slender, evenly conical, acuminate. Mesosternal lobes separated by a space a little less than the width of the lobes themselves.

General color dark olive-green with the usual longitudinal pallid lines and the broad band of black on the sides of head, pronotum and pleura separating these lines of yellow as described for both *T. surinama* and *T. phila*. Base of the anterior and median femora tinged with coral-red; the apical lobes or geniculæ of the middle femora

larger and more rounded then in *surinama*, the superior apical spine short and heavy.

The type is the property of the Carnegie Museum and belongs to Acc. No. 5058.

Genus COPIOCERA Burmeister.

Copiocera BURMEISTER, Handb. Ent., II, pp. 602, 611 (1838); STÅL, Bihang Svensk. Akad. Handl., V, no. 4, p. 38 (1878); BRUNER, Biol. Cent.-Amer., Orth., II, pp. 213, 263 (1913); REHN, Proc. Acad. Nat. Sci. Phil., 1913, pp. 94–96, figs. 7, 8.

Glaphyracris WALKER, Cat. Derm. Salt. Brit. Mus., IV, p. 653 (1870).

This genus is composed of moderately large, elongate, duskily colored insects, the majority of the species of which have their abdomens more or less conspicuously ornamented with orange or red maculations. They are distributed throughout South America from the Isthmus of Panama to northern Argentina. Up to the present time nine, or possibly ten, supposed species have been recognized and described. Two others are now added. These may be separated by the annexed key:

SYNOPSIS OF THE SPECIES OF COPIOCERA.

A. Smaller (♂, 28–31 mm.; ♀, 30–34 mm.).

b. Antennæ with their basal segments somewhat flattened, subensiform, dorsum of the pronotum and occiput provided with a median dusky longitudinal line . . . . . *eucera* Marschall.

bb. Antennæ filiform, in nowise subensiform.

c. Abdomen varicolored, provided above with orange or reddish maculations or ground.

d. Abdomen with the dorsum blood-red, the sides and underside black . . . . . *hæmatonata* Burmeister.

dd. Abdomen above pale sanguineous, with the sides flavo-maculate . . . . . *læta* Gerstæcker.

cc. Abdomen not varicolored.

d. Abdomen red. Sides of the pronotum concolorous or unicolored . . . . . *nigricans* Walker.

dd. Abdomen olivaceous, becoming darker above. Sides of the pronotum marked with a large orange area . . *collaris* Bruner.

AA. Larger (♂, 32–36 mm.; ♀, 42–48 mm.).

b. Antennæ somewhat robust, subensiform, the basal joints somewhat dilated and flattened.

c. Dorsum of the occiput and the pronotum provided with a longitudinal black line. Antennæ red . . . . . *erythrogaster* Perty.

cc. Dorsum of the head and the pronotum not provided with a longitudinal fuscous line. Antennæ black . . . . . *surinamensis* Rehn.

bb. Antennæ slender, filiform, the sub-basal joints not noticeably flattened or dilated.

c. General color greenish olive above, paler below; anterior and middle legs more or less sanguineous.

d. Smaller (♂, 32–35 mm.; tegmina 24–37.5 mm.).

e. Abdomen without red or orange-colored maculations. Anterior margin of the pronotum and the inner face and lower edge of the hind femora concolorous.

lepida Gerstæcker.*

cc. Abdomen brightly and largely red maculate. Anterior margin of the pronotum narrowly yellow-bordered, followed by a narrow collar of black. Inner face and lower margin of hind femora bright blood-red.

formosa sp. nov.

dd. Larger (♂, 36 mm.; tegmina 32 mm.). Hind tibiæ dusky vinaceous ..... *boliviana* sp. nov.

cc. General color darker.

d. Fusco-olivaceous, moderately slender . . *specularis* Gerstæcker.

dd. Reddish brown, robust ..... *austera* Gerstæcker,

114. **Copiocera surinamensis** Rehn.

Copiocera surinamensis REHN, Proc. Acad. Nat. Sci. Philad., Mch. 1913, pp. 94–96, figs. 7, 8.

I am referring a single male specimen belonging to this genus to Rehn's *C. surinamensis*. It is from the Mana River in French Guiana, where it was taken in May, 1917. C. M. Acc. No. 6008.

Its measurements are: Length of body, ♂, 30 mm.; of pronotum, 4.75 mm.; of tegmina, 25 mm.; of hind femora, 13.5 mm. In color it agrees well with Rehn's description of his female type, save that the anterior and median femora are brighter, almost blood-red.

115. **Copiocera lepida** Gerstæcker?

Copiocera lepida GERSTÆCKER, Mitth. Ver. Neu-Vorpomm. u. Rügen, XX, p. 34, no. 28 (1889); KIRBY, Syn. Cat. Orth., III, p. 420 (1910).

A single female specimen of a *Copiocera* found in the collection now being studied is referred with some hesitation to *C. lepida* of Gerstaecker. It might, however, be referable to *C. prasina* Rehn, the description of which I did not have before me at the time of determining the material in hand. This specimen comes from Benevides, Pará, Brazil, near the place where Rehn's type was obtained. It was taken by S. M. Klages in October, 1918. C. M. Acc. No. 6174.

* Rehn's *C. prasina* possibly belongs about here in the table.

116. **Copiocera formosa** sp. nov.

This is a very beautiful species, having the general appearance of *lepida*, *prasina*, and *boliviana*, but differs from all of them in several respects other than in coloration.

Moderately slender and longer-winged than usual. Head, pronotum, pleura, outer face of the hind femora and most of the intermediate portion and the apex of the anterior femora, together with the front tibiæ bright olive-green; inner face and lower sulcus of the hind femora bright blood-red. Greater portion of the dorsal sclerites of the abdomen likewise of this color, the extreme edges alone narrowly bordered with black. Venter flavous, tinged lightly with rose. Anterior and lower margins of the pronotum, together with the carinæ bordering the insertion of the legs, narrowly white, or pale citron-yellow; the anterior edge of the pronotum of the same color, followed by a wider band or collar of deep black. Hind tibiæ bright red, somewhat darkened exteriorly, the spines black. Antennæ black, without the usual pallid apical joints. Apex of the hind femora having the genicular area mostly black, varied above with a rather large triangular, and at the sides a small rounded patch of yellow, also with a pregenicular annulus of the same color. Coxæ of all the legs and basal half of the anterior pair strongly tinged with reddish purple.

Vertex between the eyes a little wider than the diameter of the basal antennal joint, the fastigium of the vertex a little elongate, rather widely and deeply sulcate, this sulcation somewhat continuous with that of the frontal costa; the latter broadly, rather deeply and roundly, sulcate from its start to the transverse facial depression, beyond which it quickly fades away; the lateral walls sharp; pronotum short, its surface coarsely and closely punctulate, the transverse sulci straight, fairly deeply impressed; anterior and posterior margins of the disc rounded, the median carina only present on the posterior lobe. Tegmina of normal width, rather elongate and with the veinlets few; this last mentioned feature is especially noticeable on the dorsal and costal fields, but is also apparent even on the disc, where there is a well-defined intercalary vein. Anterior and middle legs small and very slender, the femora scarcely at all enlarged or inflated; the posterior femora also very slender; hind tibiæ few-spined externally, on one leg two- and on the other three-spined, and the spines located apically; internally provided with the normal nine spines. Apex of the male abdomen of the usual form, the cerci long,

cylindrical, straight, the supra-anal plate smooth, red; outer or apical margins of the last ventral segment flavous, the disc black, its middle slightly and angulately produced. Prosternal spine very large and transverse. Ivory-white.

Length of body, ♂, 33.5 mm.; of pronotum, 5 mm.; of tegmina, 31.5 mm.; of hind femora, 15 mm.; of antennæ, 20 mm.

The type, a male, and the only specimen at hand, is from the Mana River, French Guiana, where it was collected in June, 1917, by S. M. Klages. C. M. Acc. No. 6008.

117. **Copiocera boliviana** sp. nov.

A moderately large but slender insect with the head, thorax, tegmina, and outer face of the hind femora dark grass-green or light olive-green. Inner face and lower sulcus of the hind femora and the femora of the anterior and middle legs above deep carmine. Hind tibiæ also tinged with carmine, although somewhat infuscated. Abdomen above pallid, but strongly tinged with vinaceous pink, the base, apex, and extreme lateral edges of all the dorsal sclerites infuscated; ventral surface olivaceous, the prosternal spine dirty cream-color. Antennæ filiform, black, except the two basal and four or five apical joints, which are pallid, a little longer than the hind femora. Eyes moderately prominent, bronze, or brassy. Pronotum with the median longitudinal carina tinged with vinaceous. Apical portion of the hind femora largely dirty white, except the inner lobes, which are dull black. Wings light fuscous, but with the immediate base cerulean, the veins dark.

Length of body, ♂, 36.5 mm.; of pronotum, 6 mm.; of tegmina, 32 mm.; of hind femora, 17 mm.

Habitat: The only specimen at hand, the type, bears the label "Las Juntas (250 M.), Department Sta. Cruz, Boliv., Steinbach." It was taken in December, 1913. C. M. Acc. No. 5060.

This insect seems to come nearest to *C. lepida* Gerstæcker, from which it differs in its larger size and longer tegmina, besides in the color-markings of the abdomen.

118. **Copiocera austera** Gerstæcker.

Copiocera austera GERSTÆCKER, Mitth. Ver. Neu-Vorpomm. u. Rügen, XX, p. 36 (1889); IB., Charakt. einer Reihe bemerk. Orth., p. 78 (1888).

Four specimens, two males and two females, from Las Juntas,

Santa Cruz, Bolivia, are referred to Gerstæcker's *austera*. They were taken at an elevation of from 250 to 300 meters above sea-level by J. Steinbach. C. M. Acc. No. 5060. One male from Buena Vista and a female from the Rio Japacani, eastern Bolivia, are also referred to this species. They were likewise taken by Steinbach. C. M. Acc. No. 5573.

Genus ZOSPERAMERUS Bruner.

Zosperamerus BRUNER, Biol. Cent.-Amer., Orth., II, p. 214, 274 (1907-8); IB., Ann. Carnegie Mus., VIII, p. 94 (1911).

There is at hand a single female specimen of a locust of this genus, which seems to be undescribed. In order to show its relationship to the forms already known the synoptic key published in a former volume of the ANNALS (VIII, p. 94) is modified to include it and herewith presented. A second species is also included in material which has arrived later.

SYNOPSIS OF THE SPECIES OF ZOSPERAMERUS.

A. Size smaller (♀, 20 to 22 mm.; ♂, 17 mm.). General color greenish olive to dark bruneo-cinerous or even ferruginous, varied with bands and mottlings of dirty white or testaceous and black.

b. Femora of all the legs conspicuously banded with pallid and fuscous. [Nicaragua, Central America.] ..... *zonatipes* Bruner.

bb. Femora less conspicuously, or not at all, banded.

c. Face, cheeks, lateral lobes of the pronotum, pleura, and the hind femora conspicuously marked with dirty white patches [Peru]. *albopictus* Bruner.

cc. Face, cheeks, lateral lobes of the pronotum, pleura and the femora very obscurely, or not at all, thus marked.

d. Pallid markings on face, cheeks, lateral lobes of the pronotum, pleura, and hind femora testaceous. [Pará, Brazil.] *brasiliensis* Bruner.

dd. Insect entirely without pallid maculations or bands on legs. Pronotum and tegmina vittate with black. Hind femora olive-green, the knees ferruginous. [Bolivia.] *vittatus* sp. nov.

AA. Size larger (♀, (?), ♂, 27 mm.). General color luteous, varied with red and black [Pará, Brazil] ..... *marginalis* Walker.

119. **Zosperamerus brasiliensis** Bruner.

Zosperamerus brasiliensis BRUNER, Ann. Carnegie Mus., VIII, pp. 94-96 (1911).

The present species is represented in the collection before me by a single female. It comes from Uassa Island, Uassa Swamp, where it was taken in June, 1918, by S. M. Klages. C. M. Acc. No. 6167.

120. **Zosperamerus vittatus** sp. nov.

The smallest representative of the genus so far as known, and easily separated from the other species by the entire absence of pallid maculations. Head, pronotum, meso- and metathorax, and tegmina bruneo-ferruginous, quadrivittate with black.

Head about as broad as the anterior margin of the pronotum; the front somewhat oblique, the occiput rounded; vertex between the large prominent eyes very narrow, its width no more, or scarcely as great, as the diameter of the slender antennæ; fastigium of the vertex depressed, rather small, about as long as wide, gently sulcate, and separated from the frontal costa by an arcuate, blunt, transverse ridge; the costa somewhat produced above the antennæ, plane, its greatest width a little more than twice that of the vertex, gradually narrowing below, sulcate just above the ocellus and below, almost terminating in the middle of the front at the rather large transverse callosities of the face. The latter coarsely rugose-punctulate; the lateral facial carinæ coarse, gently bowed outward at their middle and reaching the clypeus. Antennæ slender, about one-fourth longer than the head and the pronotum combined, the basal joint rather large. Pronotum punctulate, a little longer than wide, expanding posteriorly, the anterior margin sinuate, the posterior one widely rounded; median carina of equal prominence throughout, thrice severed by the transverse sulci, the last about one-third the length of the pronotum from its hing margin; the lateral carinæ wanting. Tegmina gently tapering, the apex rounded and reaching the hind edge of the eighth abdominal segment; wings reaching the tips of the tegmina, strongly infuscated at least apically, the disc and base not visible in the only specimen before me. Hind femora robust, about reaching the tip of the abdomen. Valves of the ovipositor, especially the upper pair, heavy, and coarsely toothed, the apex a little curved upwards, lower pair smaller, weaker, and much shorter; the supra-anal plate moderately large, its general form triangular, greatly arched at middle, and provided with an apical prolongation or finger, which is longitudinally sulcate. Mesosternal lobes widely separated, the prosternal spine acuminate. Hind tibiæ and tarsi hirsute, the former with five spines on the outer edge, seven internally; the hind tarsi with the first joint much longer than the second and about equal to the third.

Length of body, ♀, 20 mm.; of pronotum, 4 mm.; of tegmina, 11 mm.; of hind femora, 10.5 mm.

Habitat: Las Juntas, Department of Santa Cruz, Bolivia, where it was captured at an elevation above sea-level of 250 meters, in December, 1913, by J. Steinbach. C. M. Acc. No. 5060.

Genus ADELOTETTIX Bruner.

Adelotettix BRUNER, Horæ Soc. Ent. Rossicæ, XXXIX, p. 476 (1910); IB., Ann. Carnegie Mus., VIII, pp. 485–486, footnote (1913).

This genus, as stated by me in these ANNALS (Vol. VIII, p. 97), is confined to neotropical America. At least three species have already been described. A fourth appears now to be at hand. They may be recognized by the subjoined key, which is a modification of one prepared by me and appearing in the paper above cited.

SYNOPSIS OF THE SPECIES OF ADELOTETTIX.

A. Tegmina rather sparsely veined, especially apically.

b. Hind tibiæ brunneo-testaceous, nine-spined on both edges. The pronotum collared with black. [Yucatan.]. . . . . *collaris* Bruner.

bb. Hind tibiæ more or less colored with vinaceous or red, fewer-spined on both edges.

c. Hind tibiæ with the basal half obscure cinereous, the apical portion deep red. Pronotum not collared with black, wings vitreous, strongly infuscated apically . . . . . *obscurus* Bruner.

cc. Hind tibiæ vinaceous red. Pronotum pale, bordered and collared with black. Wings cerulean, but little infuscated apically [Cayenne] . . . . . *cæruleipennis* sp. nov.

AA. Tegmina profusely veined, even on the apical half. Hind tibiæ and tarsi vinaceous red [Pará, Brazil] . . . . . *brunneus* Bruner.

121. **Adelotettix cæruleipennis** sp. nov.

Related to both *collaris* and *obscurus*, but distinct, as shown by reference to the above key of species. Especially characterized by the blue wings and the pale-bordered as well as pale-collared pronotum.

Size above medium, rather robust, the front and cheeks below the eyes rather closely, but not deeply, punctate; the pronotum and pleura of meso- and metathorax strongly and profusely punctate. Head a little wider than the anterior edge of the pronotum, the occiput rather short and bulging; eyes large and prominent, about two-fifths longer than the anterior margin of the cheeks, separated at the vertex by a space a little greater than the diameter of the basal antennal joint, somewhat depressed and gently sulcate; the fastigium of the vertex not quite horizontal, a trifle longer than its basal width, longitudinally

carinated at middle, its lateral edges straight and converging gently forward, the extreme apex truncate and separated from the costa by a transverse ridge which is elevated at the center. Frontal costa prominent between the antennæ, where it is about one-half wider than the vertex, plane, or minutely and sparsely punctulate, suddenly lowered at the ocellus and below, where it is sulcate, its sides pinched at the transverse facial depression; lateral or facial carinæ prominent, straight, divergent, and reaching the base of the clypeus at its outer angles, apparently continuous as prominent longitudinal ridges on the mandibles. Antennæ black, robust, a trifle longer than the head and pronotum together, the apical four joints pallid. Pronotum selliform, its anterior lobe cylindrical, the posterior lobe flattened above, and with its sides rather strongly divergent, the last transverse sulcus located at about the middle, the median carina plainly apparent on the hind, sub-obliterated on the anterior, lobes; anterior margin somewhat rounded at its middle, the hind margin subangulate. Tegmina and wings fully developed, reaching beyond the apex of both the hind femora and the abdomen, rather sparsely veined, especially on the apical two-fifths. Hind femora robust, not reaching the apex of the abdomen; anterior and median legs small, the femora but little enlarged; the hind tibiæ and tarsi lengthily hirsute, the latter with the second joint two-thirds as long as the first, the former eight-spined interiorly, seven-spined externally. Prosternal spine robust, short, its apex broadly rounded; interspace between the mesosternal lobes about as wide as the lobes themselves, the inner margins of which are broadly rounded.

General color of insect above dark bruneo-olivaceous, below and the front tinged with pale testaceo-ferruginous. Wings largely deep cerulean, the veins apically fuliginous and the intervening membrane a little infuscated.

Length of body, ♀, 39 mm.; of pronotum, 7.5 mm.; of tegmina, 34 mm.; of hind femora, 18 mm.

The only specimen at hand, the type, comes from Cayenne, French Guiana, where it was taken in February, 1917, by S. M. Klages. C. M. Acc. No. 5873.

Genus BUCEPHALACRIS Giglio-Tos.

Bucephalacris GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 30 (1894); BRUNER, Ann. Carnegie Mus., VIII, p. 91 (1911).

The remarks offered by me, *l. c.*, p. 91, will give the reader such meager information as we possess concerning these apparently rare locusts. Since that paper appeared Rehn has described the species *falcifer*, and now there seems to be still another represented by a single male from eastern Bolivia. The table used for the separation of the four species including the two described by me in the ANNALS (*l. c.*, pp. 91–94) may be modified so as to include both *falcifer* Rehn and the new one now at hand. It follows:

SYNOPSIS OF THE SPECIES OF BUCEPHALACRIS.

A. Form rather graceful, cylindrical, or subcylindrical. Tegmina and wings a little shorter than the abdomen; the former with comparatively few veins. Hind tibiæ glaucous.

b. General color olivaceous, the tegmina tinged with rose or vinaceous. Size smaller (♂, ?; ♀, 23–25 mm.).

c. Head large and decidedly wider than the front edge of the pronotum . . . . . *borellii* Giglio-Tos.

cc. Head smaller, but little wider than the front edge of the pronotum. *fuscipennis* Brunner.

bb. General color dull grayish brown, the tegmina not tinted with rose or vinaceous.

c. Size larger (♀, 30 mm.). Hind femora provided with three fuscous bands, inner face and lower sulcus of the femora blood-red. *paraguayensis* Bruner.

cc. Size smaller (♂, 20 mm.). Hind femora provided with two dim fuscous bands, their inner face and lower sulcus flavous. *boliviana* sp. nov.

AA. Form rather robust. Tegmina considerably shorter than the abdomen; the former rather closely veined. Hind tibiæ coral-red.

b. Head about as wide as high. Upper lateral edges of the pronotum conspicuously banded lengthwise with fuscous. Length of the body greater (♀, 28.5 mm.) . . . . . *corallipes* Bruner.

bb. Head higher than wide. Upper lateral edges of the pronotum not conspicuously banded lengthwise with fuscous. Length of the body less (♂, 17.6 mm.; ♀, 25.8 mm. . . . . *falcifer* Rehn.

122. **Bucephalacris boliviana** sp. nov.

A medium-sized insect which is possibly most nearly related to the species *B. paraguayensis* Bruner and *B. borellii* Giglio-Tos.

Head large, decidedly wider than the anterior edge of the pronotum, the occiput short, bullate; the eyes very large and prominent, fully twice as long as the anterior edge of the cheeks, separated above at the

vertex by a space only a trifle greater than the diameter of the second antennal joint, the fastigium of the vertex depressed in front, somewhat broader at its base than the length, the anterior edge broadly truncate. Frontal costa prominent above between the antennæ, almost twice the width of the vertex, its surface coarsely punctulate, below the ocellus narrowing one-half and sulcate, continuous to the clypeus. Antennæ filiform, moderately coarse, a little longer than the hind femora. Front sloping to the rear. Pronotum short, the hind lobe shortest, and with its sides a little divergent caudad; hind margin subtruncate, the anterior edge at middle widely and shallowly emarginate. Tegmina and wings about a fifth shorter than the abdomen. Legs rather robust, the anterior and middle pairs with inflated femora, the hind pair also rather robust; the hind tarsi and tibiæ lengthly and rather profusely hirsute, the former with the three joints about equal in length. Prosternal spine bullate, large, hairy. Last ventral segment of the abdomen of the male somewhat longer than wide, its apex blunt, entire; cerci broad at base, emarginately and roundly narrowed from above to one-fifth the basal width, and then bowed inwards and expanding into a rounded, banner-like, gently hollowed spoon, as wide across as the basal width of the cercus.

General color of insect dark wood-brown tinged with olivaceous on the sides and the disc of the pronotum, the tegmina, cheeks, pleura, and upper side of abdomen; legs somewhat paler, the hind femora showing traces of two fuscous transverse bands above, cheeks below and back of the eyes, middle of sides of the pronotum and pleura showing dim traces of pallid maculations; genicular arches, inner genicular lobes and bases of hind tibiæ infuscated; outer margin of the banner-like apex of cerci bordered with black; antennæ dark ferruginous.

Length of body, ♂, 20 mm.; of pronotum, 3.5 mm.; of tegmina, 12.5 mm.; of hind femora, 10 mm.

Habitat: The only specimen, the type, comes from Buena Vista in eastern Bolivia, where it was taken by J. Steinbach. C. M. Acc. No. 5573.

Genus PHÆOPARIA Stål.

Phœoparia STÅL, Recens. Orth., I, pp. 36, 56 (1873); IB., Syst. Acrid., pp. 57–59 (1878); BRUNER, Biol. Cent.-Amer., Orth., II, pp. 215, 277 (1907–8).

123. **Phæoparia boliviana** sp. nov.

Related to *linea-alba* Linnæus and *castanea* Brunner, but larger, and with more or less well-defined maculations on the proportionately longer tegmina. General color brunneo-ferruginous, variegated with flecks and mottlings of piceous on the body, legs, and tegmina. Tegmina plainly, but very narrowly, marked with the oblique pallid interrupted line, so characteristic of the former of the two species, from which that species derived its name, and with which it has been compared.

Length of body, ♂, 31 mm., ♀, 46 mm.; of pronotum, ♂, 6 mm., ♀, 8 mm.; of tegmina, ♂, 31 mm., ♀, 41 mm.; of hind femora, ♂, 18 mm., ♀, 25 mm.

Habitat: The male type is from the Province del Sara and the female from Quatro-Ojos, Department of Santa Cruz, Bolivia. The former was collected during the period March–April, at an elevation of 350 meters, and the latter in November, 1913, at an elevation of 300 meters above sea-level. In addition there are two males which were taken, one at Quatro-Ojos, and the other at Las Juntas in the Department of Santa Cruz. All of this material was collected by J. Steinbach.

124. **Phæoparia castanea** (Brunner).

Opomala castanea BRUNNER, Verh. Zoöl.-Bot. Ges. Wien, XI, p. 225 (1861).
Phaeoparia castanea STÅL, Bihang. Svensk. Akad. Handl., V (4), p. 57 (1878); BRUNER, Biol. Cent. Amer., Orth., II, p. 278 (1908).

There are three males and three females before me from the Mana River and one male and a female from Pied Saut, Oyapok River, French Guiana, collected by S. M. Klages in December, 1917. C. M. Acc. No. 6111. Also a pair, male and female, from the Upper Rocana in Northern Pará, Brazil, collected by the same party in July, 1918. C. M. Acc. No. 6175.

Genus ALEUAS Stål.

Aleuas STÅL, Bihang. Svensk. Akad. Handl., V, (4), pp. 25, 69 (1878); GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, III, no. 311, p. 47 (1898); BRUNER, Proc. U. S. Nat. Mus., XXX, pp. 642, 667 (1906).

125. **Aleuas vitticollis** Stål.

Three males are placed here. They were taken by J. Steinbach in February, 1913, in the Province del Sara, Bolivia, at an elevation of 350 meters above sea-level. C. M. Acc. No. 5058.

Genus JODACRIS Giglio-Tos.

Jodacris GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XII, no. 302, p. 32, note (1897); IB., XIII, no. 311, p. 47 (1898); BRUNER, Proc. U. S. Nat. Mus., VIII, p. 104 (1911).

126. **Jodacris ferruginea** (Giglio-Tos).

Anniceris ferruginea GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no, 184, p. 30 (1894) in part.

Jodacris ferruginea GIGLIO-TOS, *l. c.*, XII, pp. 32–33 (1897) in part; BRUNER. Locusts of Argent., p. 67 (1900), etc.

A single male of this interesting locust is at hand. It comes from Buena Vista in eastern Bolivia, where it was taken by J. Steinbach. C. M. Acc. No. 5573.

Genus ABRACRIS Walker.

Abracris WALKER, Cat. Dermap. Salt. Brit. Mus., IV, p. 642 (1870); KIRBY, Syn. Cat. Orth., III, p. 428 (1910); BRUNER, Ann. Carnegie Mus., VIII, p. 107 (1911).

127. **Abracris nebulosa** (Bruner).

Jodacris (?) *nebulosa* BRUNER, Locusts of Argent., p. 67 (1900).
Omalotettix nebulosa BRUNER, Proc. U. S. Nat. Mus., XXX, p. 673 (1906).
Abracris nebulosa KIRBY, *l. c.*, p. 428 (1910).

Several specimens of both sexes of this species are at hand. They come from the Province del Sara, Buena Vista, and Rio Japacani, Bolivia, where they were taken by J. Steinbach in February, March, April, and November. C. M. Acc. Nos. 5058 and 5673. Several specimens (seven males and three females) are also at hand from Cayenne, French Guiana, where they were taken in February and March, 1917. C. M. Acc. Nos. 5817, 5873, and 5897. The representatives of this and the other species of the genus are quite common in the forests of the localities in which they occur, where they are to be found among fallen leaves and on low herbaceous vegetation and the stems of woody plants as well.

Possibly a few of the Bolivian specimens referred to above should be assigned to *A. signatipes* Bruner, which according to Rehn are the same as *A. delecta* Walker.

128. **Abracris cæruleipennis** (Bruner).

Jodacris (?) *cæruleipennis* BRUNER, *l. c.*, pp. 66, 67 (1900).
Omalotettix cæruleipennis BRUNER, *l. c.*, pp. 673, 674 (1906).
Abracris cæruleipennis KIRBY, *l. c.*, p. 428 (1910).

Several specimens of the two sexes were taken at the same localities and dates as those listed under the preceding species. They form parts of the same accessions, and were collected by J. Steinbach.

129. **Abracris meridionalis** (Bruner).

Omalotettix meridionalis BRUNER, Biol. Cent.-Amer., Orth., II, pp. 280, 281 (1908).
Abracris meridionalis KIRBY, *l. c.*, p. 428 (1910).

In addition to representatives of the preceding two species of *Abracris* I find at least four females of an insect, which seems to agree exactly with the description of *meridionalis*, and several other specimens, which do not entirely thus agree. They are from the Province del Sara, Bolivia, and were taken at practically the same season of the year by J. Steinbach. C. M. Acc. No. 5058. There is also one female from Buena Vista. C. M. Acc. No. 5573. In addition to the above I find three females labelled "Cayenne, French Guiana, March and May, 1917." The latter belong to C. M. Acc. Nos. 5873 and 6008.

Genus VILERNA Stål.

Vilerna STÅL, Recens. Orth., I, pp. 38, 71 (1873); BRUNNER, Ann. Mus. Génève, XXXIII, p. 139 (1893); GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XIII, no. 311, p. 47 (1898); KIRBY, Syn. Cat. Orth., III, p. 429 (1910). For further bibliography of the genus see Kirby, *l. c.*

130. **Vilerna æneo-oculata** (De Geer).

Acrydium æneo-oculatum DE GEER, Mém. Ins., III, p. 502, pl. 42, fig. 11 (1773).
Vilerna æneo-oculata STÅL, *l. c.*, p. 71 (1873); BRUNER, Biol. Cent.-Amer., Orth., II, p. 285 (1908). For further synonymy see Kirby, *l. c.*, p. 430.

The collections here reported upon contain the following material which is referred to this species: two males and one female, Cayenne, French Guiana, Jan.–March, 1917, C. M. Acc. Nos. 5817, 5873, 5897; one male, Pied Saut, Oyapok River, French Guiana, S. M. Klages, C. M. Acc. No. 6173; and a single female collected on Cayari Island in the Uassa Swamp, in May, 1918. The latter belongs to C. M. Acc. No. 6177.

Genus CALETODES Giglio-Tos.

Caletodes GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XIII, no. 311, pp. 47, 58 (1898); KIRBY, Syn. Cat. Orth., III, p. 431 (1910).

Several locusts coming from the Province del Sara, Bolivia, are referred to this genus.

131. **Caletodes alatus** Giglio-Tos.

Caletodes alatus GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XIII, no. 311, p. 58 (1898).

There are five females in the collection which were taken in Bolivia in October, 1913, at an elevation of 350 meters above sea-level, by J. Steinbach. C. M. Acc. No. 5058.

Genus XIPHIOLA Bolivar.

Xiphiola BOLIVAR, Act. Soc. Españ. Hist. Nat., XXV, p. 17 (1896); GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XIII, p. 48 (1898); BRUNER, Proc. U. S. Nat. Mus., XXX, pp. 642, 674 (1906); IB., Ann. Carnegie Mus., VIII, p. 116 (1911).

This genus is composed of small or medium-sized locusts having striking color-patterns. They must dwell among rank vegetation growing in shady forests, upon the stems of low shrubs, or upon the bark of trees. Only two species are known.

132. **Xiphiola cyanoptera** Bolivar?

Xiphiola cyanoptera BOLIVAR, *l. c.*, p. 17 (1896); GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XV, no. 377, p. 5 (1900).

Although this insect has been reported heretofore only from Peru, there are four specimens of a locust before me, which apparently belong to Bolivar's *X. cyanoptera*. They come from the Mana River in French Guiana, where they were taken in May and June, 1917. C. M. Acc. No. 6008.

I do not happen at present to have before me Bolivar's paper containing the original description of the species *cyanoptera*, and the quotations from it made by Giglio-Tos in his tabulated comparison with his new *X. borellii* do not appear sufficient to permit of my being entirely certain as to the identity.

133. **Xiphiola borellii** Giglio-Tos.

Xiphiola borellii, GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XV, no. 377, p. 5 (1900); BRUNER, Proc. U. S. Nat. Mus., XXX, p. 674 (1906); IB., Ann. Carnegie Mus., VIII, p. 116 (1911).

The present species is represented by a male and a female from Buena Vista and a single male from the Rio Japacani in eastern Bolivia, where they were taken by J. Steinbach. C. M. Acc. No. 5573.

This insect seems to be rather common in portions of northern

Argentina, in Paraguay, in southern Brazil, and in eastern Bolivia. It apparently frequents rather open woods, where it may be found near the ground among fallen leaves, on twigs, herbs, etc., if we are permitted to base our surmises upon its general color-scheme.

Genus OSMILIOLA Giglio-Tos.

Osmiliola GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, XII, no. 302, p. 32 (1897); IB., XIII, no. 311, p. 48 (1898); BRUNER, 2d Rep. Locust Comm. B. Aires, pp. 54, 68 (1900); KIRBY, Syn. Cat. Orth., III, p. 432 (1910).

134. **Osmiliola aurita** Giglio-Tos.

Osmiliola aurita GIGLIO-TOS, *l. c.*, XII, no. 302, p. 33 (1897); BRUNER, Proc. U. S. Nat. Mus., XXX, p. 674 (1906); IB., Annals Carnegie Mus., VIII, p. 116 (1911).

There is a single female which I am inclined to place here, although it does not exactly agree with the original description given by Giglio-Tos. It is either a rare insect, or else its habits are such as to preclude its capture by ordinary methods of collecting. Its rather wide distribution appears to indicate that it may be commoner than is at present believed. It has been taken heretofore in northern Argentina, in Paraguay, and Brazil. The specimen at hand comes from Buena Vista in eastern Bolivia, where it was captured by J. Steinbach. C. M. Acc. No. 5573.

Genus RHABDOSCIRTUS Bruner.

Rhabdoscirtus BRUNER, Ann. Carnegie Mus., VIII, p. 116 (1911).

The genus *Rhabdoscirtus* was erected for an insect coming from Demarara, British Guiana, and contained in the collection of the present writer.

135. **Rhabdoscirtus vittatus** Bruner.

Rhabdoscirtus vittatus BRUNER, *l. c.*, p. 117 (1911).

This species is represented by a single female from Pied Saut, Oyapok River, French Guiana, collected in November, 1917, by S. M. Klages. C. M. Acc. No. 6111.

Genus OMMATOLAMPIS Burmeister.

Ommatolampis BURMEISTER, Handb. Ent., II, p. 636 (1838). For a bibliography of the genus see KIRBY, Syn. Cat. Orth., III, p. 433.

136. **Ommatolampis peruviana** Bruner.

Ommatolampis peruviana BRUNER, Horæ Soc. Ent. Rossicæ, XXXIX, pp. 482–483, Dec. 1910.

I find a mature female of this insect taken near the Rio Japacani in February, 1915, and also an injured immature specimen, labeled "Buena Vista, E. Bolivia." Both were collected by J. Steinbach. C. M. Acc. No. 5573.

Genus EUSITALCES Bruner.

Eusitalces BRUNER, Ann. Carnegie Mus., VIII, p. 142 (1911).

137. **Eusitalces vulneratus** sp. nov.

Considerably larger and somewhat more robust than *E. vittatus*, the type of the genus, which was described in the ANNALS, *l. c.*, pp, 143–144. General color greenish olive, black, and yellow, the pronotum above and on the sides conspicuously marked with large orange-red maculæ.

Head of moderate size, as wide as the anterior margin of the pronotum, the occiput rounded, short, the vertex narrow, not sulcate, about as wide as the diameter of the second antennal joint (♂) or a trifle greater (♀); fastigium of the vertex depressed, subtriangular, a little broader at its base than long, not at all sulcate, but rather with its disc gently convex, the sides and anterior margins coarsely carinate; the frontal costa a little prominent and plane, provided with a few coarse punctures between the antennæ, about as wide, or a trifle wider than the diameter of the first antennal joint, very inconspicuous below, but nevertheless reaching the clypeus. Eyes rather prominent, in the male about one-third, in the female one-fourth, longer than the cheeks below them. Antennæ filiform, somewhat longer than the head and pronotum combined. Pronotum coarsely punctulate, more closely so on the posterior lobe, expanding caudad; transverse sulci profound; the median carina prominent, coarse, severed by the posterior sulcus; the lateral carinæ absent; anterior margin sinuous, a little advanced on the occiput, and with the middle widely emarginate; posterior edge triangular and likewise emarginate at its middle. Tegmina lateral, small, covering the auditory apparatus, their apex about reaching (♀) or a little surpassing (♂) the hind margin of the first abdominal segment. Hind femora somewhat robust at their base,

evenly tapering apically, where they are slender; the genicular lobes triangular, acuminate; tibiæ and tarsi hirsute, the external margin of the tibiæ eight-spined instead of six-spined as in *vittatus*. Anterior and middle legs normal. Abdomen of male a little clavate apically, the last ventral segment triangular, upturned, its apex entire; supra-anal plate large, subquadrate, the lateral margins near the base elevated, sinuose, the disc at middle profoundly elevated longitudinally leaving broad lateral depressions; the marginal apophyses of the preceding segment forming slender adjacent fingers one-third the length of the plate. Cerci large, heavy at base, forked, elongate, and curved, the inner branch heavier and directed upwards, inwards, and a little to the front, their apices almost touching; the outer branch slenderer and curved backwards, upwards, and only slightly inwards; valves of the ovipositor rather long and strong, only moderately hooked; mesosternal lobes separated by a space a little wider than the width of the lobes themselves. Prosternal spine slender, acuminate, emanating from a robust quadrate elevation of the surface of the sternum.

Head with the front, middle, anterior, and lower margins of the cheeks, occiput at sides and middle, most of the disc of the fastigium, two basal joints of the antennæ, the median carina, and sides of the disc of the pronotum, middle, and sides of the dorsum of the abdominal segments and lines on the pleura, bright yellow; remainder of head, disc, and sides of the pronotum, dorsum of the abdomen, together with the sides of the meso- and metathorax, and basal abdominal segments, black. Tegmina black, with a median and dorsal vitta of yellow. Legs and lower side of body greenish olive; the geniculæ of the hind femora black, preceded by a flavous annulus. Antennæ dull ferruginous in the male, testaceous in the female.

Length of body, ♂, 18 mm., ♀, 21.5 mm.; of pronotum, ♂, 4 mm., ♀, 4.15 mm.; of tegmina, ♂ and ♀, 2 mm.; of hind femora, ♂ and ♀, 5 mm.

Habitat: One male and one female, from the Province del Sara, Bolivia, were found at an elevation of 350 meters above sea-level. They were taken in October, 1913, by J. Steinbach. C. M. Acc. No. 5059. A second male is also at hand. It was taken by the same collector at Quatro-Ojos, Department of Santa Cruz, Bolivia, and is made the male type because of its better condition. Two additional males and a female bear the locality label "Buena Vista,

E. Bolivia." They were also taken by Steinbach. C. M. Acc. No. 5573.

Genus SCHISTOCERCA Stål.

The insects, which form the genus *Schistocerca*, are all large in body and ample in length of wing. Hence many, if not all of them, are at times apt to wander far from region to region over most of the subtropical and tropical lands of the Western Hemisphere. Like many other groups of locusts, the different forms tend to vary more or less markedly in color, as well as to a certain extent in size. A number of them change color a couple of times during their lives. Especially is this last statement true with reference to the forms which hibernate in the imaginal stage. Many of the species have been described time and again by different writers, who have had occasion to study them. This state of affairs has resulted in a rich and complicated synonymy, difficult to decide without a great amount of material from various localities and access to the types for comparison. Then, furthermore, the earlier writers made their descriptions so brief, that they apply quite as well as two or more species or forms, as we understand them today.

In the present paper, accordingly, no attempt will be made to discuss the synonymy and probable distribution of the several species coming under notice.

138. **Schistocerca flavolinea** sp. nov.

A remarkably large and strikingly colored insect, which runs to the vicinity of *flavofasciata* in Scudder's Table of the Species of *Schistocerca* as published on pages 442–447 of Vol. XXXIV of the Proceedings of the American Academy of Arts and Sciences. It naturally belongs with my species, *Schistocerca formosa* and *Schistocerca magnifica*, when size and beauty is considered. The former comes from Colombia, and the latter from the Bahamas. Our new form is an east Bolivian insect.

Head comparatively narrow, not quite as wide as the anterior margin of the pronotum, its depth one-half greater than the width; viewed laterally the front is broadly rounded, and somewhat retreating below. Occiput short, rather full or rounded; the vertex between the eyes not depressed and about as wide as the lesser diameter of the inconspicuous eyes; the fastigium of the vertex is gently depressed,

short, fully twice as wide at its base as long, scarcely, sulcate and without definite bounding carinæ; the frontal costa is rather prominent, the sides almost parallel, sulcate throughout, and rather coarsely punctulate at sides and on the carinæ, especially above and towards the clypeus; the antennæ are long and slender, reaching considerably beyond the caudal margin of the pronotum. The latter with the sides of the anterior lobe nearly parallel, the sides of the hind lobe rather strongly divergent caudad; disc somewhat full, in front subtectate, viewed laterally gently arcuate, the hind lobe flat, the median carina rather prominent on the hind lobe, but becoming less so cephalad; transverse sulci deep, but not especially wide; the hind margin at middle forming a right angle; lateral lobes deep or high behind, the lower edge rather strongly obliquely sinuose. Legs somewhat robust and elongate. Tegmina greatly elongate, of moderate width, extending fully one-fourth of their length beyond the apex of the hind femora and the tip of the abdomen. Prosternal spine small, slender, cylindrical, nearly erect, its apex rounded.

General color brunneo-ferruginous. Middle of the occiput and the pronotum provided with a prominent longitudinal bright ferruginous band, inclining to orange, bordered on the head with black, starting in front at the very top of the frontal costa and narrowing from the last transverse sulcus of the pronotum to the apex of the disc. Lower edges of the lateral lobes of the pronotum rather prominently bordered with a wide but irregular yellowish patch. Costal margin of the tegmina on their basal third also provided with a conspicuous testaceous stripe. Antennæ bright orange-ferruginous, exterior face of the hind femora dirty white; their genicular arcs and lobes testaceous, the lunules more or less piceous; hind tibiæ brunneo-cinerous, tinged with purplish.

Length of body, ♀, 66 mm.; of pronotum, 14 mm.; of tegmina, 65.5 mm.; of hind femora, 38 mm.

Habitat: The type, the only specimen seen, comes from the Rio Japacani in eastern Bolivia, where it was collected by J. Steinbach in February, 1915. C. M. Acc. No. 5573.

139. **Schistocerca flavofasciata** (De Geer).

A female specimen coming from the "Province del Sara, Bolivia" and taken by J. Steinbach in April, 1913, is referred here. Several

specimens taken in French Guiana are also referred to this species, though in the latter case with some doubt. C. M. Acc. Nos. 5873, 6008, and 6173.

140. **Schistocerca fimbriata** (Thunberg).

Gryllus fimbriatus THUNBERG, Mém. Acad. St. Petersb., V, p. 247 (1915).

I have here placed a single female coming from Quatro-Ojos, in the Department of Santa Cruz, Bolivia. It was taken in November, 1913, at an altitude of 300 meters above sea-level.

141. **Schistocerca pallens** (Thunberg).

Gryllus pallens THUNBERG, Mém. Acad. St. Petersb., V, p. 237 (1815).

Among the material coming from Nueva Gerona on the Isle of Pines, West Indies, are three females, which are referred to Thunbergs *Gryllus pallens*.

142. **Schistocerca inscripta** (Walker).

Cyrtacanthacris inscripta WALKER, Cat. Derm. Salt. Brit. Mus., III, p. 550 (1870).
Acridium inscriptum THOMAS, Syn. Acrid. N. Amer., p. 228 (1873).
Schistocerca inscripta SCUDDER, Proc. Amer. Acad. Arts & Sci., XXXIV, pp. 444, 461 (1899).

The collections coming from Nueva Gerona, Isle of Pines, contain twenty-one females and seven males of Walker's *S. inscripta*.

There seems to be very little variation both as to size and coloration in specimens of this species.

143. **Schistocerca americana** (Drury).

Gryllus americanus DRURY, Ill. Nat. Hist., I, p. 128, pl. 49, fig. 2 (1770), etc.

Two males and a female of this widely distributed species are at hand from Cayenne, French Guiana, taken February, 1917. C. M. Acc. No. 5873.

144. **Schistocerca** sp.?

In addition to the forms mentioned above there are three nymphs of possibly still another species of *Schistocerca* at hand. They come from the Isle of Pines and were taken at Nueva Gerona.

Genus MONACHIDIUM Serville.

Monachidium SERVILLE, Ann. Sci. Nat., XXII, p. 281 (1831). For further bibliography of this genus see Kirby, Syn. Cat. Orth., III, p. 463.

145. **Monachidium lunum** (Johansen).

Gryllus lunus JOHANSEN, Amœn. Acad., VI, p. 397 (1763). For synonymy see Kirby, *l. c.*

A single female specimen of this remarkably and strikingly colored locust is at hand. It comes from Pied Saut, Oyapok River, French Guiana, where it was taken in March, 1918, by S. M. Klages. C. M. Acc. No. 6173.

Genus DICHROPLUS Stål.

Dichroplus STÅL, Recens. Orth., I, pp. 78 (1873); BRUNER, Proc. U. S. Nat. Mus., XXX, pp. 643, 677 (1906), etc.

146. **Dichroplus punctulatus** (Thunberg).

Gryllus punctulatus THUNBERG, Mém. Acad. St. Petersb., IX, pp. 395, 408 (1824).
Dichroplus punctulatus GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 21 (1884), etc.

Rio Bermejo, Province of Salta, Argentina, one female, taken May, 1914, at an altitude of 400 meters above sea-level; and one male and three females from the Province del Sara, Bolivia, taken in December, 1913, and March and April, 1912, by J. Steinbach. In addition to these there are three males and two females collected at Cayenne, French Guiana, during February and March, C. M. Acc. Nos. 5873 and 5897; and two males from the Mana River, French Guiana, May, 1917, C. M. Acc. No. 6008.

147. **Dichroplus exilis** Goglio-Tos.

Dichroplus exilis GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 23 (1894), etc.

The collections made by J. Steinbach in the Province del Sara, Bolivia, contain a pair of this species. C. M. Acc. No. 5058. They were taken during the period March–April, 1913, at an elevation of 350 M. above sea-level. There is also a single female from Buena Vista, eastern Bolivia. C. M. Acc. No. 5573.

Genus PARASCOPAS Bruner.

Parascopas BRUNER, Proc. U. S. Nat. Mus., XXX, pp. 643, 689 (June, 1906); GIGLIO-TOS, Boll. Soc. Españ. Hist. Nat., VI, p. 293 (July, 1906).
Scopas GIGLIO-TOS (*nec* BON.), Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 28 (1894), XIII, no. 311, p. 50.

148. **Parascopas obesus** (Giglio-Tos).

Scopas obesus GIGLIO-TOS, Boll. Mus. Zoöl. Anat. Comp. Torino, IX, no. 184, p. 28 (1894).

Parascopas obesus BRUNER, Proc. U. S. Nat. Mus., XXX, p. 689 (1906).

The collections made by J. Steinbach at Buena Vista, eastern Bolivia contain a pair of *P. obesus* Giglio-Tos *in coitu*. C. M. Acc. No. 5573.

149. **Parascopas sanguineus** Bruner.

Parascopas sanguineus BRUNER, Ent. News, XXI, p. 306–7 (1910).

Two males and two females of this interesting species are at hand. They come from the Province del Sara, Bolivia, where they were collected during the period embraced in the months of February to April inclusive. They come from an altitude of 350 meters above sea-level. C. M. Acc. No. 5058. An additional male bears the label "Rio Japacani, E. Bolivia, Feb. 1915" It also was taken by Steinbach, and belongs to C. M. Acc. No. 5573.

Genus LEIOTETTIX Bruner.

Leiotettis BRUNER, Proc. U. S. Nat. Mus., XXX, pp. 643, 684 (1906); REHN, Proc. Acad. Nat. Sci. Phil., 1907, p. 188.

150. **Leiotettix viridis** Bruner.

Leiotettix viridis BRUNER, *l. c.*, p. 685 (1906); REHN, *l. c.*, p. 188 (1907).

The collection made by J. Steinbach during November and December, 1912, contains two males and one female, and possibly a third male, which are referable to this species. They come from an elevation of 350 meters above sea-level in the Province del Sara, Bolivia. C. M. Acc. No. 5058.

The third male, just referred to, differs from the others in having the sides of the pronotum provided with a well defined dusky band and the four basal abdominal segments at their sides largely glossy black. Otherwise, so far as the structure of the apical portions of the abdomen is concerned, it is practically the same as typical *viridis*. In addition I find a male from Buena Vista, Bolivia, which belongs to C. M. Acc. No. 5573.

151. **Leiotettix sanguineus** Bruner.

Leiotettix sanguineus BRUNER, *l. c.*, pp. 685, 687 (1906); REHN, *l. c.*, p. 187 (1907).

One specimen of each sex from the "Province del Sara, Bolivia,"

collected by J. Steinbach, in March and April, 1913, are referred here. They were taken at about 350 meters above sea-level. C. M. Acc. No. 5058.

Genus PARADICHROPLUS Brunner.

Paradichroplus BRUNNER, Ann. Mus. Génève, XXXIII, p. 145 (1893); GIGLIO-TOS, Boll. Mus. Zool. Anat. Comp. Torino, IX, no. 184, pp. 20, 25 (1884); XIII, no. 311, p. 50 (1898); BRUNER, Proc. U. S. Nat. Mus., XXX, p. 692 (1906); IB., Ann. Carnegie Mus., VIII, p. 137 (1911).

152. **Paradichroplus fusiformis** Giglio-Tos.

Paradichroplus fusiformis GIGLIO-TOS, *l. c.*, XII, no. 302, p. 35 (1897); BRUNER, *l. c.*, XXX, pp. 692, 693 (1906); VIII, pp. 138, 140 (1911).

Two females and one male of this genus are referred to *P. fusiformis* Giglio-Tos.

They are from the Province del Sara, Bolivia, where they were taken by J. Steinbach. The male specimen bears the date November, 1911, and one of the females March, April, 1913. They were taken at an altitude of approximately 350 meters above sea-level. C. M. Acc. No. 5058.

153. **Paradichroplus geniculatus** Bruner.

Dichroplus geniculatus BRUNER, Ann. Carnegie Mus., VIII, pp. 138, 139 (1911).

There are three specimens of this species before me, one male and two females. They were taken at the same locality as the preceding. The male and one female bear the date of February, 1913, while the other female was captured in November, 1911. They were all collected by Mr. J. Steinbach. C. M. Acc. No. 5058. Two additional females from Buena Vista, E. Bolivia, were taken by the same collector. The latter belong to C. M. Acc. No. 5573.

154. **Paradichroplus sanguineus** sp. nov.

A small, and in fact the smallest, species thus far recognized. It comes next to *fusiformis* Giglio-Tos in the synoptical key as given on pages 499–500, of Vol. VIII of these ANNALS. In order to include it in that table, the key would have to be modified as follows:

AA. Hind tibiæ provided with eight spines in the outer row.
b. Hind tibiæ of the normal form, etc. * * *
c. Larger (♀, 22–28 mm.).
cc. Smaller (♀, 18–21 mm.).
d. Color testaceo-ferruginous, etc.

dd. Color more or less markedly olivaceous. Hind tibiæ greenish. Internal and external discs of the hind femora not especially infuscated.

e. Genicular area of the hind femora marked with black lunules.

f. Cheeks, lower part of the lateral lobes of the pronotum and the legs pale yellowish. Abdomen at its sides from the base to its middle, nigro-maculate. *fusiformis* Giglio-Tos,

ff. Cheeks, lower part of the lateral lobes of the pronotum testaceous, the legs greenish olive. Abdomen not maculate with black, but with the sides of segments 1–6 largely bright blood-red. . . . *sanguineus* sp. nov.

Head of moderate size, about as wide as the anterior edge of the pronotum, the front moderately oblique, the occiput rather short, and strongly rounded; vertex strongly depressed, narrower than the diameter of the basal antennal joint, rather deeply and linearly sulcate, the sulcation becoming more profound and much deeper anteriorly upon the fastigium of the vertex; the latter greatly depressed and of moderate size, a little wider than long, and with heavy lateral walls; frontal costa rather prominent, wide, continuous to the clypeus, and broadly sulcate throughout; antennæ filiform, greenish-yellow, about reaching the apex of the first abdominal segment. Pronotum gently widening behind, about as long as its greatest width, the surface punctulate, on the hind lobe more densely so; transverse sulci profound; the anterior and posterior margins of the disc a little roundly emarginate. Tegmina small, lateral, not quite reaching the hind margin of the first abdominal segment, about three times as long as their greatest width, the disc provided with three rather heavy longitudinal veins. Legs robust, the hind femora extending beyond the tip of the abdomen of the male by the length of the genicular portion; hind tibiæ strongly hirsute, eight-spined externally and nine-spined internally. Tip of the abdomen scarcely enlarged, the last ventral segment short, smooth, the apical margin squarely truncate; supra-anal plate rather large, a fourth longer than its basal width, evenly, but not rapidly, narrowing towards its apex, the lateral edges gently raised and giving the plate a hollowed appearance, the apex suddenly, but obliquely, narrowed, and ending in an acute angle; the basal half, or a little more, provided with a deep, acute, and heavily bounded V-shaped sulcus in or above which are two long pointed finger-like projections from the hind margin of the preceding segment; cerci

simple, their length about two and one-half times their greatest basal width, acuminate, hirsute; the prosternal spine rather robust at its base, evenly tapering, the apex slenderly acuminate and directed gently cephalad.

General color greenish testaceous, a little paler below. Sides of the head back of the eyes, and sides of the pronotum marked with a moderately broad longitudinal fuscous band; middle of occiput, the disc of pronotum at middle, the transverse sulci of latter, the dorsal abdominal carina, and the apical margins of three segments also narrowly infuscated. Legs greenish, the hind tibiæ dark sea-green. Eyes castaneous. Tegmina dark ferruginous, the interspaces between the veins fuscous. Sides of the abdominal segments one to six and metapleura bright blood-red.

Length of body, ♂, 15 mm.; of pronotum, 3 mm.; of tegmina, 2.3 mm.; of hind femora, 9.5 mm.

Habitat: The single specimen, a male, and the type of the species, comes from Buena Vista in eastern Bolivia, where it was taken by J. Steinbach. C. M. Acc. No. 5573.

Genus OSMILIA Stål.

Osmilia STÅL, Recens. Orth., I, p. 68 (1873); KIRBY, Syn. Cat. Orth., III, p. 539 (1910). For further bibliography see Kirby, *l. c.*

155. **Osmilia flavolineata** (De Geer).

Acrydium flavolineatum DE GEER, Mém. Ins., III, p. 497, pl. 42, fig. 4 (1773). For synonymy see Kirby, *l. c.*

This species is represented in the material now being reported upon by the following specimens: One male and a female, Cayenne, French Guiana, February and March, 1917, C. M. Acc. No. 5873; one male, one female, from the Mana River, French Guiana, May. The latter pair belongs to C. M. Acc. No. 6008.

Genus RHYTIDICHROTA Stål.

Rhytidichrota STÅL, Recens. Orth., I, pp. 35, 54 (1873); IB., Bihang. Svensk. Akad. Handl., V, no. 4, pp. 34, 75 (1878); BRUNNER, Ann. Mus. Géneve, XXXIII, p. 148 (1893); BRUNER, Biol. Centr.-Am., Orthop., II, p. 337 (1908); IB. Ann. Carn. Mus., VIII, p. 141 (1910); IB. *l. c.*, p. 505 (1911).

The insects, which are included in this genus, are all confined to the tropical portions of America. They are of medium size, apterous, and

may be recognized by their having the hind femora provided apically below with rather large tubercles and spines or teeth. Nine species have already been described and now a tenth is added. They may be separated by the accompanying key modified from that given by me in Volume II of the Orthoptera of the *Biologia Centrali-Americana*.

A. Posterior tibiæ armed externally with seven spines.

b. Larger (♂, 22 to 24 mm.; ♀, 25–32 mm.).

c. Antennæ distinctly ensiform. General color obscure, greenish olive; the hind tibiæ apically, along with the tarsi, miniaceous. *ensicornis* Stål.

cc. Antennæ very narrowly and obsoletely subensiform or linear.

d. General color varying from coral-red to subolivaceous black. Surface of the head, thorax, and the basal abdominal segments, above granulose . . . . . *varicolor* Stål.

dd. General color yellowish-testaceous. Surface of the head, thorax, and basal abdominal segments rugose above. *sellata* Stål.

bb. Smaller (♂, 15–17 mm.; ♀, 22 mm.).

c. Surface rather densely pilose. Geniculæ of the hind femora minute sanguineous . . . . . *pilosa* Stål.

cc. Surface with but few hairs. Geniculæ of the hind femora black. Cerci robust . . . . . *peruviana* Bruner.

AA. Posterior tibiæ armed externally with eight spines.

b. Dorsum of the pronotum and the basal abdominal segment on each side provided with smooth, somewhat elevated, callosities.

c. Body and the head above strongly rugoso-punctulate. General color clay-yellow . . . . . *antennata* Stål.

cc. Body and the head above less strongly punctulate. Color subferruginous-olivaceous, the head black. Legs greenish olive, the hind geniculæ subsanguineous . . . . . *lævifrons* Stål.

bb. Dorsum of the pronotum and the basal abdominal segment above without the callosities, but sometimes with glabrous areas.

c. Larger (♂, 27 mm.; ♀, ?). The glabrous areas present, but inconspicuous. General color pale yellowish olive. Dorsal field of the abdominal segments provided with two prominent circular black spots, one on either side . . . . . *boliviana* sp. nov.

cc. Smaller (♂, 14.5 mm.; ♀, 22 mm., ?). Without the glabrous areas referred to above. General color variable.

d. Frontal costa plain, not sulcate. Body and head above densely and strongly rugoso-punctate. Color yellowish testaceous. *turgida* Stål.

dd. Frontal costa sulcate. Body and head above less densely punctulate and hirsute. Color obscure olive-green. *brunneri* Stål.

156. **Rhytidichrota peruviana** Bruner.

Rhytidichrota peruviana BRUNER, Horæ Soc. Ent. Rossicæ, XXXIX, p. 487 (1910).

Two males from Las Juntas, Santa Cruz, Bolivia, belong here. They were collected by J. Steinbach in December, 1913, at an elevation of 250 meters above sea-level. C. M. Acc. No. 5060.

157. **Rhytidichrota boliviana** sp. nov.

Related to *lævifrons* and *antennata* of Stål, but lacking the shining callosities on the pronotum and the basal abdominal segment, as mentioned in connection with the descriptions of those species. Large and robust. Inner, lower, and outer faces of the hind femora strongly tinged with carmine.

Head of moderate size, about as broad as the anterior margin of the pronotum; the occiput strongly rounded, comparatively smooth; the eyes fairly prominent, nearly twice as long as the anterior margin of the cheeks below them, separated above by a narrow space, the sides of which are strongly carinated, the carinæ diverging anteriorly on the basal portion of the fastigium of the vertex; this latter of medium size, quadrate, and with the disc depressed and rugoso-granulate; frontal costa somewhat prominent above between the antennæ, about twice the width of the vertex, plain above, becoming sulcate towards the central ocellus and continuing to the base of the clypeus. Antennæ rather robust, but not at all ensiform, or subensiform, as in *ensicornis* and allies, about as long as the hind femora. Pronotum with its surface shining, though coarsely and shallowly punctulate, the anterior lobe a little more than twice the length of the posterior, and with the sides parallel; the hind lobe with its sides divergent posteriorly, the transverse sulci moderately strongly impressed, the median carina present only on the hind lobe, very faint; the front margin rounded, shallowly emarginate at its middle, the hind margin straight. Dorsum of pro- and mesonotum and basal abdominal segments rugoso-punctulate. Body entirely apterous. Anterior and middle legs robust, the femora swollen; hind femora long, and rather robust at their base, gently tapering apically, the upper carina serrate basally, the lower carina strongly toothed on its apical half; the hind tibiæ heavy, their outer margin armed with eight, the inner with nine spines. Cerci short, robust, a little tapering, directed upwards, the cephalic margin produced into an inwardly

directed forked process about two-thirds as long as the heavier basal part. Apex of the abdomen terminating in a short cone. Supra-anal plate of the type specimen obscured by being depressed apically and covered by the soft male appendages that were protruded before drying. Prosternal spine small, acuminate, on a robust quadrate base.

General color pale yellowish olive, with the legs a little more greenish. Dorsum of abdominal segments three to seven inclusive conspicuously marked with two black spots, one on either side near the longitudinal carina. Basal lower half of the hind femora tinged interiorly, externally, and below with carmine. Apex of two basal abdominal segments above piceous. Upper third of the outer face and apical half of the inner face of the hind femora infuscated. Eyes castaneous. Antennæ pale at base, becoming darker apically.

Length of body, ♂, 27 mm.; of pronotum, 5.85 mm.; of hind femora, 16 mm.

Habitat: The only specimen at hand, the type, comes from the Province del Sara, Bolivia, where it was taken in the period including March–April, 1913, by J. Steinbach at an elevation of 350 meters above sea-level. C. M. Acc. No. 5058. I also find among additional material received since the above description of the male was drawn up another male and two females. These come from Buena Vista, Bolivia, and were taken by the same collector and belong to C. M. Acc. No. 5573.

The female does not differ materially from the male except in size and in the greatly reduced size of the large spines on the lower carina of the apical half of the hind femora. The measurements of this sex are: length of body, 30 mm.; of pronotum, 5.5 mm.; of hind femora, 16 mm.

II. ORTHOPTERA FROM AFRICA, BEING A REPORT UPON SOME SALTATORIA MAINLY FROM CAMEROON CONTAINED IN THE CARNEGIE MUSEUM.

By Lawrence Bruner.

The present article is based on two major and two or three minor collections and odd specimens of orthopteroid insects which have come into the possession of the Carnegie Museum during the past four or five years. There are, all told, three hundred and eighty-two specimens.* The species are divided among the suborders as follows: *Locustoidea*, forty-eight; *Achetoidea*, sixteen; and *Tettigonoidea*, forty-one; or approximately one hundred and five. Nine of these species appear to be new, and are thus characterized in this paper, while a few of the Achetoidea have been reserved for further study.

While the Orthoptera, as well as several other groups of insects, occurring in the general region, from which most of the material now being studied has come, have been quite extensively collected and worked over by entomologists, so far as certain isolated localities are concerned, no doubt there remain many other species, both common and rare, to be added. In fact, it is the opinion of the writer that tropical Africa as a whole is practically *terra incognita*, so far as its insect-fauna is concerned.

Family TETRIGIDÆ.

The grouse-locusts comprise a very interesting group, and are widely distributed over the surface of the earth. Of course they are most numerously represented in the warmer and more humid regions, where they abound in forests, jungles, swamps, or mountain slopes; in open

* *Note:* It is proper to observe that not all of the representatives of certain of the commoner species of African Saltatorial Orthoptera were sent to Dr. Bruner, at the time the insects were submitted to him for study. In some cases where the species was represented by scores of specimens it was thought hardly worth while to burden him with the care of all of them.—W. J. Holland.

country, as prairies and even semi-deserts; or wherever there is water, or damp ground to which they are partial. In looking for these insects the collector succeeds best when he carefully examines the margins of streams, low beaches, and open localities in swamps; paths, roads, and other openings in forests and jungles; tree-trunks, moss-covered rocks, fallen leaves and other rubbish which covers the ground. In such environment they lurk, protected by their dull and imitative colors. Besides being protectively colored and having great resemblances to fragments of dead vegetation, particles of bark, earth, pebbles, and similar objects, they also show a tendency to feign death or to quietly perch so as to avoid notice. Some forms even crawl or dive beneath the surface of water and cling to submerged sticks, stones, etc., where they remain for long intervals at a time.

Under these conditions it usually happens that ordinary collectors of insects when visiting a region overlook most of the Tettrigidæ. Only the specialist, or persons who are especially in quest of them, and who knows their habits and haunts, are likely to take a fair percentage of those species which the locality contains.

A complete list of these insects known from Africa at present only includes about seventy-five species. There would undoubtedly be several times that number listed, if all were known.

Fully one-half of these insects reported from Africa are recorded from the region whence the collections now being reported upon came. Notwithstanding this fact there are less than a dozen forms at hand.

Genus HIPPODES Karsch.

Hippodes KARSCH, Ent. Nachr., XVI, p. 24, pl. 17 (1890); HANCOCK, Genera Ins., Fasc. 48, pp. 17–24, fig. 7 (1908).

This genus was established for the reception of a wingless grouse-locust coming from West Africa. The present collection contains another apparently closely related, but smaller species, which is here described.

1. **Hippodes hopei** sp. nov.

Of medium size, moderately robust, without tegmina and wings, and with the apex of the pronotum reaching only one-half the distance to the tip of the ovipositor and to the middle of the hind femora.

Body somewhat depressed, the pronotum robust, somewhat tectate and arched on its anterior half, the median carina prominent through-

out, but more decidedly so in advance of its middle, the surface granulose, but not at all rugose or tuberculate; anterior margin truncate, the apex rounded and widely subtruncate; the lateral lobes provided with a sinuation immediately back of the lateral lobe, which is obliquely rounded and directed a little to the rear and outward. Tegmina and wings wanting. Head rather broad, set into the front edge of the pronotum almost to the eyes; the vertex convex, almost as wide again as one of the eyes, its front roundly advanced, its anterior margin without a transverse carina and gradually merging with the upper portion of the front; the frontal costa continuing above as a prominent carina through the middle of the vertex and extending backward halfway to the anterior edge of the pronotum, rather profoundly sulcate, the rami diverging somewhat strongly from a little above the posterior ocelli to a point drawn across the face from below the lower ocellus, and, when viewed laterally, roundly prominent between the antennæ. The latter arise just within a line drawn between the lower edge of the eyes, are slender and of moderate length. Anterior and middle femora elongate, several times as long as wide, the carinæ not at all foliate or lobate; hind femora robust; hind tibiæ with few spines, irregularly placed, the first joint of the tarsi at least one and one-half times as long as the third. Valves of the ovipositor robust and evenly and strongly serrated.

General color dark fuscous, the apical half of the pronotum and markings on the hind femora bruneo-testaceous, the tibiæ obscurely fasciate. Lower outer edge of the hind femora black. Abdomen varied with dusky and pale markings.

Length of body, ♀, 10 mm.; of pronotum, 6.5 mm.; of hind femora, 6 mm.

Habitat: Batanga, Cameroon,[1] F. H. Hope, Collector. Only the type, a female, is at hand. C. M. Acc. No. 5293.

Genus CRIOTETTIX Bolivar.

Criotettix BOLIVAR, Bol. Ann. Soc. Ent. Belg., XXXI, pp. 184, 193, 222 (1887); HANCOCK, Spol. Zeyl., II, pp. 108, 128 (1904); IB., Gen. Ins., Fasc. 48, Orth., Acrid., Tetrig., pp. 22, 27 (1906).

[1] The name of this part of Africa in the English language is Cameroon. When the Germans seized it, they Germanicized the name, calling it "Kamerun." Now that the French are administering it, they write the name "Cameroun." I propose to stick to the English spelling, which antedates all others. W. J. Holland.

2. **Criotettix nigellus** Bolivar.

Criotettix nigellus BOLIVAR, *l. c.*, XXXI, pp. 185, 223, 225 (1887); IB., Mem. Soc. Españ. Hist. Nat., I, p. 213 (1905).

Four specimens of grouse-locusts contained in the collections at hand are referred to this species. Three of them were taken by A. I. Good at Lolodorf, Cameroon, and the other by F. H. Hope at Batanga, Cameroon. They were collected in November and March. C. M. Acc. Nos. 5264 and 5293.

Bolivar in his description of the species does not mention the pallid color of the apex of the abdomen, the meso- and metapleura, and the lateral spines of pronotum, as found on these specimens. Aside from this discrepency they agree very well with his description of *nigellus*.

Genus MORPHOPUS Bolivar.

Morphopus BOLIVAR, Bol. Mém. Soc. Españ. Hist. Nat., I, p. 216 (1905); HANCOCK, Gen. Ins., Fasc. 48, Orth. Acrid. Tetrig., pp. 31, 37 (1906).

3. **Morphopus affinis** Bolivar.

Morphopus affinis BOLIVAR, Bol. Mém. Soc. Españ. Hist. Nat., I, p. 216 (1905); HANCOCK, Mém. Soc. Ent. Belg., XIV, p. 85, no. 7 (1908).

The material taken at Batanga, contains one male and two females, which were collected by F. H. Hope in February, 1914. A single female is also at hand from Lolodorf. The latter specimen was taken in November, 1910, by A. I. Good.

Genus PARATETTIX Bolivar.

Paratettix BOLIVAR, Bol. Ann. Soc. Ent. Belg., XXXI, pp. 187, 195, 270 (1887); also many authors. See Kirby, Syn. Cat. Orth., III, p. 32 (1910).

4. **Paratettix meridionalis** (Rambur)?

Tetrix meridionalis RAMBUR, Faune Andal., II, p. 65 (1839). For synonymy see Kirby, *l. c.*, p. 32.

The collections made by A. I. Good at Lolodorf contain eleven specimens of a *Paratettix*, which I am inclined to refer to *meridionalis*, although somewhat outside of its recorded habitat. C. M. Acc. No. 5264. They were taken in May, 1914, and November and December, 1913. An additional specimen, but somewhat smaller, and taken by the same collector, is likewise placed here.

5. **Paratettix wilverthi** Bolivar?

Paratettix wilverthi BOLIVAR, Mém. Soc. Ent. Belg., XVI, p. 86 (1908).

There are five specimens belonging to this genus, a single female and four males, which rather closely approach Bolivar's description of *P. wilverthi*, and they are accordingly referred to it. The female and two males were collected by A. I. Good at Lolodorf, while the other males are from Batanga and were taken by F. H. Hope. Only the female agrees very closely with the characterization of the species as given by Bolivar. The others vary more or less.

Genus ACRYDIUM Geoffroy.

Acrydium GEOFFROY, Hist. Ins., I, p. 390 (1762); KIRBY, Syn. Cat. Orth., III, p. 35 (1910). For a more extended bibliography of the genus see Kirby, *l. c.*

This is the genus *Tetrix* of Latreille and *Tettix* of Charpentier and later writers. However, according to priority, and other rules of zoölogical nomenclature, it seems to be necessary to discard these later and almost universally used names for that of Geoffroy.

According to the characters used for the separation of this genus, at least two distinct forms must be referred to it.

6. **Acrydium gratiosus** (Karsch)?

Tettix gratiosus KARSCH, Berlin. Ent. Zeitschr., XXXVIII, p. 120 (1893).
Acrydium gratiosum KIRBY, Syn. Cat. Orth., III, p. 44 (1910).

A single female coming from Lolodorf, Cameroon, thus determined. It was taken by A. I. Good on November 12, 1913. C. M. Acc. No. 5264.

7. **Acrydium wælbrœchi** (Bolivar)?

Tettix wælbroœchi BOLIVAR, Mém. Soc. Ent. Belg., XVI, p. 87 (1908).
Acrydium wælbrœchi KIRBY, Syn. Cat. Orth., III, p. 49 (1910).

There are two males of a second species, which were also taken by Mr. Good in November, 1913, and are referred with some doubt to Bolivar's *Tettix waelbrœcki*, originally described from Kinchassa in the Congo. They form part of the same accession as the preceding.

Family TRUXALIDÆ.

Africa is the habitat of a large number of genera and species of truxaline locusts. The present collection, however, does not contain many representatives of the group, since only about half a dozen

species are found in the material being studied and upon which I am reporting.

Genus ACRIDA Stål.

Acrida STÅL, Recens. Orth., I, pp. 88, 95 (1873); BURR, Trans. Ent. Soc. Lond., 1902, pp. 149, 155.

8. **Acrida propinqua** Burr.

Acrida propinqua BURR, Trans. Ent. Soc. Lond., 1902, pp. 157, 171.

Five specimens belonging to the genus *Acrida* are at hand. They are referred to Burr's *propinqua*. Two males and one female come from Batanga, where they were taken by F. H. Hope. One female bears the label "Lolodorf, Kamerun." It was collected by A. I. Good. A third female bears the label "Congo, Antisdel." The latter specimen belongs to C. M. Acc. No. 2315.

Genus ODONTOMELUS Bolivar.

Odontomelus BOLIVAR, Bol. An. Soc. Españ. Hist. Nat., XIX, p. 309 (1890); KARSCH, Berlin. Ent. Zeitschr., XXXVIII, pp. 53, 61 (1893); BURR, Trans. Ent. Soc. Lond., 1902, p. 154.

9. **Odontomelus bifrensis** Bolivar.

Odontomelus bifrensis BOLIVAR, Mem. Soc. Españ. Hist. Nat., I, p. 219 (1905).

Three males coming from Batanga are placed here. They were taken by F. H. Hope in April, 1914. C. M. Acc. No. 5293.

Genus RODUNIA Bolivar.

Rodunia BOLIVAR, Bol. Mém. Soc. Ent. Belg., XVI, p. 99, note (1908); KIRBY, Syn. Cat. Orth., III, p. 139 (1910).

The representatives of this African genus bear a general resemblance to various species of *Orphulella* and allied American forms. Like them, they also appear to be genuine "grasshoppers" and are fairly common wherever found. Seventeen species are recognized by Kirby (*l. c.*, pp. 139–40).

The genus, as at present accepted, is composed of forms which were originally referred to at least four separate genera by their respective authors. Even now there seems to be quite a confusion as to their exact affinities, and only for convenience in assisting in their determination is the annexed imperfect key for their separation added.

At least eight of these forms are found in or near the regions in which the present material was taken.

SYNOPSIS OF THE SPECIES OF RODUNIA.

A. Larger (♂, 19–33 mm.; ♀, 25–36+ mm.).

b. Lateral carinæ of the pronotum parallel, straight. Antennæ ensiform, or more or less strongly flattened at their base.

c. Smaller (♂, 21 mm.; ♀, 27 mm.).

d. Pale green or testaceous.

e. The dorsum always pale green ..... *læta* (Bolivar).

ee. The dorsum testaceous, sanguineo-punctate. *sanguinolenta* (Bolivar).

dd. Color smoky gray. Hind margin of the pronotum almost a right angle ..... *angustata* (Bolivar).

cc. Larger (♂, 28–33 mm.; ♀, ?).

d. Testaceous or green. Smaller (♂, 28 mm.; ♀, 35 mm.). *basalis* (Walker).

dd. Fulvous; head and pronotum with two white lateral stripes. Larger (♂, 33 mm.; ♀, ?) ..... *interlineata* (Walker).

bb. Lateral carinæ of the pronotum not parallel, either bowed or divergent. Antennæ variable.

c. Pronotum with its lateral carinæ divergent behind.

d. Antennæ subensiform or ensiform ..... *producta* (Walker).

dd. Antennæ filiform, or but little flattened basally.

e. Green or greenish testaceous. Vertex in front of the eyes somewhat angulate, longer than wide (Sudan, West Africa) ..... *tricolor* (Karny).

ee. Olivaceous yellow. Vertex in front of the eyes short, rounded. (East Africa, in vicinity of Mozambique.) *mossambicensis* (Brancsic).

cc. Pronotum with the lateral carinæ bowed inwards. Hind tibiæ red. Wings pellucid ..... *inclyta* (Walker).

AA. Smaller (♂, 11.5–18 mm.; ♀, 17–20 mm.).

b. Lateral carinæ of the pronotum parallel. Antennæ subensiform or filiform.

c. Lateral carinæ becoming subobsolete posteriorly. General color rufo-fuscous ..... *tricarinata* (Bolivar).

cc. Lateral carinæ continuous to the hind margin. Testaceous. *recta* (Walker).

bb. Lateral carinæ of pronotum variable, but not parallel throughout. Antennæ more or less ensiform.

c. Pronotal carinæ flexuous in front of their middle, divergent behind. *schulthessi* Kirby.

cc. Pronotal carinæ divergent posteriorly.

d. Antennæ with their basal joints strongly flattened, more or less ensiform.

e. General color rufous or rufo-testaceous (British East Africa) ..... *rufescens* (Kirby).

ee. General color greenish-yellow or yellowish-green.

f. Moderately robust (West Africa) .... *duria* (Karsch).

ff. Rather slender (East Africa) ..... *insipida* (Karsch).

dd. Antennæ filiform, or with the basal joints but little flattened.

e. Antennal joints a little flattened at base. Body somewhat robust. Griseo-testaceous (British East Africa). *elegans* (Karny).

ee. Antennæ filiform. Body slender. Flavo-testaceous (Sudan) ..... *pharaonis* (Karny).

10. **Rodunia duria** (Karsch).

Duronia duria KARSCH, Stettin. Ent. Zeitschr., LVII, p. 252 (1906).
Rodunia duria KIRBY, Syn. Cat. Orth., III, p. 140 (1910).

Five males and three females of a small greenish grasshopper from Batanga, are referred to *Duronia duria* Karsch. They were collected by F. H. Hope, in April and May, 1914. C. M. Acc. No. 5293.

11. **Rodunia pharaonis** (Karny)?

Phlœoba pharaonis KARNY, Sitz. Akad. Wiss. Wien., Math.-Nat. Klasse, CXVI, pt. i, p. 103, pl. 3, fig. 52 (1907).
Rodunia pharaonis KIRBY, Syn. Cat. Orth., III, p. 140 (1910).

A second species of the genus is represented by four males and the same number of females, which were also taken by Hope at the same locality as the preceding, from February to April, inclusive.

While these specimens do not agree in every respect with the original description of *P. pharaonis*, they approach it more closely than they do any of the other described species.

Genus CHIRISTA Karsch.

Chirista KARSCH, Berlin. Ent. Zeitschr., XXXVIII, pp. 54, 75 (1893); KIRBY, Syn. Cat. Orth., III, p. 142 (1910).

Chirista, like the preceding genus, is made up of several allied species which recall the American group *Orphulini*. As suggested in connection with *Rodunia* these insects are no doubt true "grasshoppers," and live among the grasses and other low-growing plants in meadows and openings in the forests, or even in open or prairie country.

12. **Chirista compta** Walker.

Stenobothrus comptus WALKER, Cat. Derm. Salt. Brit. Mus., IV, p. 762 (1870).
Duronia virgula BOLIVAR, An. Soc. Españ. Hist. Nat., XIX, p. 310 (1890). For further synonymy see Kirby, Syn. Cat. Orth., III, p. 142 (1910).

Several specimens, nine males and four females, of a rather small locust collected by F. H. Hope at Batanga and by A. I. Good at Lolodorf, are referred to Walker's *Stenobothrus comptus*, which forms the type of the genus *Chirista*.

These specimens look very much like our *Orphulella pelidna* (Burmeister).

Genus HOLOPERCNA Karsch.

Holopercna KARSCH, Berlin. Ent. Zeitschr., XXXVI, 176 (1891).

13. **Holopercna gerstæckeri** (Bolivar).

Duronia gerstæckeri BOLIVAR, An. Soc. Españ., XIX, p. 311 (1890).
Holopercna gerstæckeri KIRBY, Syn. Cat. Orth., III, p. 143 (1910).
Holopercna cœlestis KARSCH, Stettin. Ent. Zeitschr., XXXVI, p. 177 (1891).

There are two male specimens of a locust from Lolodorf, which I refer to this species. They were collected by A. I. Good in August and October, 1913. C. M. Acc. No. 5264.

Genus RHABDOPLEA Karsch.

Rhabdoplea KARSCH, Berlin. Ent. Zeitschr., XXXVIII, pp. 54, 69 (1893); KIRBY, Syn. Cat. Orth., III, p. 147 (1910).

So far as at present known the representatives of the genus *Rhabdoplea* are confined to West Africa. Three species are known.

14. **Rhabdoplea mira** Karsch.

Rhabdoplia mira KARSCH, *l. c.*, pp. 70, 71, fig. 9 (1893).

This species is represented by one male and five females coming from Batanga. There is also a second male from the same locality, which has greater length of wing, but otherwise does not differ from the description of this sex. All were taken by F. H. Hope in March and April, 1914. C. M. Acc. No. 5293.

Family LOCUSTIDÆ (Œdipodinæ).

Genus MORPHACRIS Walker.

Morphacris WALKER, Cat. Derm. Salt. Brit. Mus., IV, p. 790 (1870); KIRBY, Syn. Cat. Orth., III, p. 218 (1910).
Cosmorhyssa STÅL, Recens. Orth., I, pp. 116, 121 (1873); SAUSSURE, Mém. Soc. Génève, XXVIII (9), pp. 50, 123 (1884), XXX (1), pp. 18, 37 (1888).

The insects belonging in this genus are found in Africa and those

parts of Europe and Asia, which border on the eastern Mediterranean. Four, or possibly five, species are known.

15. **Morphacris sulcata** (Thunberg).

Gryllus sulcatus THUNBERG, Mém. Acad., Petersb., V, p. 234 (1815), IX, pp. 396, 410 (1824).
Cosmorhyssa sulcata STÅL, Recens, Orth., I, p. 122 (1873).
Morphacris sulcata KIRBY, Syn. Cat. Orth., III, p. 219 (1910).

One female, Batanga (F. H. Hope), another of the same sex and a male, from Lolodorf (A. I. Good). C. M. Acc. Nos. 5293 and 5264.

Genus ŒDIPODA Serville.

Œdipoda SERVILLE Ann., Sci. Nat., XXII, p. 287 (1831); Ins. Orth., p. 718 (1839). For further synonymy see Kirby, Syn. Cat. Orth., III, p. 238 (1910).

16. **Œdipoda cærulescens** (Linnæus).

Gryllus Locusta cærulescens LINNEUS, Syst. Nat. (ed. 10), I, p. 432 (1758). For a rather full synonymy of this species see Kirby, *l. c.*, pp. 240–241.

There are two specimens, male and female, at hand. They were collected by Dr. W. J. Holland at Tangier, Morocco, in October, 1911. C. M. Acc. No. 4514.

Family PYRGOMORPHIDÆ.

The family *Pyrgomorphidæ* is one of the principal groups of African locusts and contains many very interesting forms. In fact, Kirby in his Synonymic Catalogue of the Orthoptera of the World, lists thirty-six distinct genera, members of which occur on the African continent and the immediately adjacent islands. Several of these locusts are mong the most gaudily colored forms known. Others are recognized as destructive to agriculture, while still others are very bizarre in their appearance.

Genus DICTYOPHORUS Thunberg.

Dictyophorus THUNBERG, Mém. Acad. Petersb., V, pp. 217, 258 (1815); KIRBY, Trans. Ent. Soc. Lond., 1902, p. 88.
Petasia SERVILLE (*nec* Stephens), Ann. Sci. Nat., XXII, p. 278 (1831); IB., Ins. Orth., p. 628 (1839); STÅL, Recens. Orth., I, pp. 12, 20 (1873), etc.
Topesia BOLIVAR, Bol. Soc. Esp. Hist. Nat., IV, p. 309 (1904); IB., Gen. Ins., Fasc. 90, Orth. Acrid. Pyrg., p. 12 (1909).

17. **Dictyophorus laticinctus** Walker.

Petasia laticincta WALKER, Cat. Derm. Salt. Brit. Mus., III, p. 544 (1870); KIRBY, Syn. Cat. Orth., III, p. 305 (1910). For further synonymy see Kirby, *l. c.*

Two female specimens belonging in the genus *Dictyophorus*, as here limited, are referred to Walker's *laticincta*. They bear the label "Congo (Antisdel), C. M. Acc. 2315."

Genus PARAPETASIA Bolivar.

Parapetasia BOLIVAR, Bol. An. Soc. Españ. Hist. Nat., XIII, pp. 25, 484, 498 (1884); IB., Bol. Soc. Esp. Hist. Nat., IV, p. 309 (1904); IB., Gen. Ins., Fasc. 90, Orth. Acrid. Pyrg., p. 13 (1909).

18. **Parapetasia femorata** Bolivar.

Parapetasia femorata BOLIVAR, *ll. cc.*, pp. 485, 498, pl. 4, figs. 28, 28*a–c* (1884); p. 309 (1904), p. 14 (1909); KARSCH, Berlin Ent. Zeitschr., XXXVII, p. 70 (1898).

A single female is at hand. It comes from Efulen, Cameroon, where it was collected by Dr. H. L. Weber.

This specimen differs somewhat from Bolivar's description, but comes much closer to it than to *P. impotens* of Karsch. The specimen before me also comes from a region much closer to the locality, from which the species was described, than to the habitat of the second species, the latter coming from a region fully two thousand miles to the eastward.

Genus TAPHRONOTA Stål.

Taphranota STÅL, Œfv. Vet.-Akad. Förh., XXX, p. 51 (1873); IB., Recens. Orth., I, pp. 11, 19 (1873); BOLIVAR, An. Soc. Españ. Hist. Nat., XIII, pp. 25, 472, 497 (1884); IB., Bol. Soc. Esp. Hist. Nat., IV, p. 394 (1904); IB., Gen. Ins., Fasc. 90, Orth. Acrid. Pyrg., p. 15 (1909).

Epamonotor KIRBY, Trans. Ent. Soc. Lond., 1902, p. 87 (immature).

All of the representatives of the genus *Taphronota*, so far as known, are confined to Africa. Fourteen species are listed in Kirby's Synonymic Catalogue of the Orthoptera.

19. **Taphronota merceti** Bolivar?

Taphronota merceti BOLIVAR, Bol. Soc. Esp. Hist. Nat., pp. 395, 398 (1904); KIRBY, Syn. Cat. Orth., III, p. 309 (1910).

A male specimen of a locust bearing the label "Congo (Antisdel). C. M. Acc. 2315" is doubtfully referred to Bolivar's *T. merceti*.

20. **Taphronota thælophora** (Stoll)?

Gryllus Locusta thælophorus STOLL, Spectres Saut., p. 32, pl. 16*b*, fig. 59 (1813).
Taphronota thælophora KIRBY, Syn. Cat. Orth., III, p. 310 (1910).

Two males, three females, and a nymph of the latter sex, seem to agree more closely with Stoll's *thælophorus* than with any of the other described species. They are accordingly referred to it. They bear the labels: "Batanga, Kamerun, F. H. Hope, Coll. C. M., Acc. 5293," 1 ♂, 2 ♀, 1 nymph; "Lolodorf, Kamerun, A. I. Good, Col. C. M. Acc. 5264," 1 ♂, 1 ♀.

Genus RUTIDODERES Westwood.

Rutidoderes WESTWOOD, in Drury, Ill. Exot. Ent., I, pp. 119, 120 (1837).
Peristegus BOLIVAR, An. Soc. Españ. Hist. Nat., XIII, pp. 25, 469, 497 (1884); IB., Bol. Soc. Esp. Hist. Nat., IV, p. 401 (1904); IB., Gen. Ins., Fasc. 90, Orth. Acrid. Pyrg., pp. 16, 17 (1909).

21. **Rutidoderes squarrosus** (Linnæus).

Gryllus Locusta squarrosus LINNÆUS, Mant. Plant., p. 533 (1771). For a rather full synonymy of this species see Kirby, Syn. Cat. Orth., III, p. 311.

There are two male specimens of this interesting locust at hand, which are from Lolodorf, where they were collected by A. I. Good in February, 1913, and July, 1914. C. M. Acc. No. 5264.

Genus ZONOCERUS Stål.

Zonocerus STÅL, Œf. Vet.-Akad. Förh., XXX (4), p. 51 (1873); IB., Recens. Orth., I, pp. 10, 16 (1873); BOLIVAR, An. Soc. Españ. Hist. Nat., XIII, pp. 25, 457, 497 (1884); IB., Bol. Soc. Esp. Hist. Nat., IV, p. 418 (1904); IB., Gen. Ins., Fasc. 90, Orth. Acrid. Pyrg., pp. 17, 19 (1909).

22. **Zonocerus variegatus** (Linnæus).

Gryllus Locusta variegatus LINNÆUS, Syst. Nat. (ed. 10), I, p. 432 (1758); IB., Mus. Ludov. Ulr., p. 144 (1764). For the synonymy of this species see Kirby Syn. Cat. Orth., III, p. 316.

The present collection contains specimens of *Z. variegatus* as follows: Batanga (F. H. Hope), 2 ♂, C. M. Acc. No. 5293; and Congo (Antisdel), 1 ♂, C. M. Acc. No. 2315.

Genus ATRACTOMORPHA Saussure.

Atractomorpha SAUSSURE, Ann. Soc. Ent. France (4), I, p. 474 (1861); STÅL, Recens. Orth., I, p. 10 (1873); BOLIVAR, An. Soc. Españ. Hist. Nat., XIII, pp. 23, 63, 495 (1884); IB., Bol. Soc. Esp. Hist. Nat., V, p. 196 (1905); IB., Gens. Ins., Fasc. 90, Orth. Acrid. Pyrg., p. 39 (1909), etc.

Representatives of the genus *Atractomorpha* are common throughout most oriental countries. Especially is this true of the warmer regions. Some of the species are the common and even destructive "grasshoppers" of the countries where found. Several of them occur in both green and testaceous color-forms, while still others possess individuals which are even strongly tinged with rufous, vinaceous, and purple hues. At least six distinct species of the genus have been recognized from African territory, only two of which are contained in the present collections.

23. **Atractomorpha aberrans** Karsch.

Atractomorpha aberrans KARSCH, Ent. Nachr., IV, p. 333 (1888); BOLIVAR, Bol. Soc. Esp. Hist. Nat., V, pp. 197, 200 (1905).

The species *aberrans* Karsch is represented by five males and five females. They were collected in April and May, 1914, at Batanga by F. H. Hope. C. M. Acc. No. 5293.

24. **Atractomorpha gerstæckeri** Bolivar.

Atractomorpha gerstæckeri BOLIVAR, An. Soc. Españ. Hist. Nat., XIII, pp. 64, 66 (1884); IB., Bol. Soc. Esp. Hist. Nat., V, pp. 198, 208 (1905).

Truxalis crenulatus BEAUVOIS (*nec* Fabricius), Ins. Afr. Amer., p. 79, Orth., pl. 3, figs. 1*a*, 1*b* (1805).

Pyrgomorpha crenulata GERSTÆCKER (*nec* Fabr.), Arch. Naturg., XXXV (1), p. 216 (1869); IB., Von der Decken's Reise in Ost-Africa, Ins., p. 34 (1869).

Four males and six females are referred to this species, which seems to be quite widely distributed. It has been found in western, eastern, and southern Africa. The specimens before me are labelled, "Congo (Antisdel), C. M. Acc. 2315," 1 ♀; "Batanga, Kamerun, F. H. Hope, Coll., C. M. Acc. No. 5293," 4 ♂, 4 ♀; and "Lolodorf, Kamerun, A. I. Good, C. M. Acc. No. 5264," 1 ♀.

Family CYRTACANTHACRIDÆ.

(Acridiidæ.)

This family of locusts contains by far the greatest number of genera and species in almost all countries of both the Orient and Occident, as well as in the larger islands of the seas. Very many of them are true "grasshoppers" *i.e.*, they live among the grasses and low herbage of meadow, prairie, hillside, mountain slopes, clearings, and like

localities. Others are just as much at home among the vegetation of swamps, and woodlands. More forms of this family than of all the others combined have become adjusted to special food-plants and peculiar haunts, from which they seldom stray, except by accident. Hence the great diversity in structure, habits, color, etc., shown by different species. A very considerable number of genera and species have become wingless, or at least subapterous, so that frequently they are passed over, by ordinary collectors, who are unfamiliar with the group. Except by orthopterists they are generally considered immature, and consequently are not taken.

Genus OXYA Serville.

Oxya SERVILLE, Ann. Sci. Nat., XXII, pp. 264, 286 (1831); IB., Ins. Orth., p. 675 (1839) and various authors to date.

This is an Old World genus and contains a number of species, which resemble each other rather closely. For the most part they are meadow-grasshoppers, and are prevailingly grass-green in color, rather slender in form, and active in their movements.

25. **Oxya hyla** Serville.

Oxya hyla SERVILLE, *l. c.*, p. 287 (1831); KIRBY, Syn. Cat. Orth., III, p. 393 (1910).
Acridium hyla SERVILLE, *l. c.*, p. 678, pl. 12, fig. 4 (1839).
Heteracris viridivittata WALKER, Cat. Derm. Salt. Brit. Mus., IV, p. 660 (1870).
Oxya serrulata KARSCH, Zoöl. Jahrb., Syst., V, p. 662, pl. 45, figs. 8, 8*a*, *b* (1891); BRUNNER VON WATTENWYL, Ann. Mus. Genova, XXXIII, pp. 151, 152 (1893).

Batanga, F. H. Hope, Collector, two males, two females; Lolodorf, one male and one female, A. I. Good, Collector.

Genus SPATHOSTERNUM Krauss.

Spathosternum KRAUSS, Sitz. Akad. Wiss. Wien., Math.-Nat. Cl., LXXVI, p. 44 (1877); STÅL, Bihang, Svensk. Akad. Handl., V (4), pp. 50, 97 (1878).

26. **Spathosternum pygmæum** Karsch.

Spathosternum pygmæum KARSCH, Berlin, Ent. Zeitschr., XXXVIII, p. 110 (1893).

Four males and two females from Batanga are referred to Karsch's *pygmæum*. They were collected by F. H. Hope in March and April, 1914. C. M. Acc. No. 5293.

Genus OXYRRHEPES Stål.

Oxyrrhepes STÅL, Œfv. Vet.-Akad. Förh., XXX (4), pp. 40, 53 (1873); IB., Recens. Orth., I, pp. 40, 79 (1873), etc.

27. **Oxyrrhepes procera** (Burmeister).

Oxya procera BURMEISTER, Handb. Ent., II, p. 635 (1838).
Oxyrrhepes procera BOLIVAR, An. Soc. Espaň. Hist. Nat., XV, p. 343 (1886).
Oxyrrhepes procerus KARSCH, Berlin. Ent. Zeitschr., XXXVIII, pp. 112, 113 (1893).

Specimens of this locust are at hand as follows: from Batanga, one male and one female (F. H. Hope, Coll.); from Lolodorf, one female (A. I. Good, Coll.); Banza Manteka, Belgian Congo, one male (A. L. Bain, Coll.).

Genus CYRTACANTHACRIS Walker.

Cyrtacanthacris WALKER, Cat. Derm. Salt. Brit. Mus., III, p. 550 (1870).
Acrydium in part, OLIVIER, Encycl. Méth., Ent., VI, p. 209 (1791). For synonymy of genus see Kirby, Syn. Cat. Orth., III, p. 446 (1910).

The insects, which are included in this genus, for almost a century have been quite generally referred to *Acridium*. According to the rules of zoölogical nomenclature, however, *Acridium* must be employed to receive the various species of *Tetrigidæ* so long referred to the genus *Tettix*, as restricted in comparatively recent years. The next available name seems to be Walker's *Cyrtacanthracris*. At least seventy-five supposedly distinct species of the genus are recorded in Kirby's Catalogue, *l. c.*, pp. 446–454.

28. **Cyrtacanthacris lineata** (Stoll).

Gryllus Locusta lineatus STOLL, Spectres Saut., p. 31, pl. 15*b*, fig. 57 (1813). For further synonymy see Kirby, *l. c.*, p. 450.

The present collection contains five specimens, two males and three females, which are referred to Stoll's *lineata*. They were taken at Lolodorf and Batanga, and were collected by A. I. Good and F. H. Hope.

29. **Cyrtacanthacris ruficornis** (Fabricius).

Gryllus ruficornis FABRICIUS, Mant. Ins., I, p. 237 (1787). For synonymy see Kirby, *l. c.*, p. 450.

Specimens are at hand as follows: a single female bearing the label "Banza Manteka, Belg. Congo, Coll. A. L. Bain, C. M. Acc. No. 4686," "Lolodorf, Kamerun, A. I. Good, Coll., C. M. Acc. 5264."

Genus SCHISTOCERCA Stål.

Schistocerca STÅL, Recens. Orth., I, p. 64 (1873), and numerous authors since.

As in the case of the preceding, this genus is composed of large and showy insects. It, however, is practically confined to the New World,

while the other is oriental in its distribution. About the same number of species belong to each. Only one species of *Schistocerca* is found east of the Atlantic, and it is supposed to have reached Africa from the Occident, where it is also rather widely distributed. The genus contains several well-known pests.

30. **Schistocerca tartarica** (Linnæus).

Gryllus (*Locusta*) *tartaricus* LINNÆUS, Syst. Nat. (Ed. 10), I, 432 (1758). For a quite full synonymy of this species see Kirby, Syn. Cat. Orth., III, p. 459.

The species is represented by two males and two females. They come from the Congo (Antisdel). C. M. Acc. No. 2315.

This insect is one of the chief migratory locusts of southern Europe and northern Africa. It is also a widely distributed species in tropical America. A very extensive literature exists, based on this and other destructive and migratory locusts.

Genus ABISARES Stål.

Abisares STÅL, Bihang, Svensk. Akad. Handl., V, (4), p. 29 (1878); BRUNNER, Ann. Mus. Genova, XXXIII, p. 143 (1893).

The present genus was established for a single African species.

31. **Abisares viridipennis** (Burmeister).

Monochidium viridipenne BURMEISTER, Handb. Ent., II, p. 626 (1838); KIRBY, Syn. Cat. Orth., III, p. 466 (1910).

Two males of a medium-sized locust from Batanga are referred to Burmeister's *Monochidium viridipenne*, for which Stål proposed the generic name *Abisares*. They were collected by F. H. Hope in April, 1914. C. M. Acc. No. 5293.

Genus COPTACRA Stål.

Coptacra STÅL, Recens. Orth., I, pp. 37, 58 (1873); BRUNNER, Ann. Mus. Genova, XXXIII, p. 143 (1893); BOLIVAR, Ann. Soc. Ent. France, LXX, p. 624 (1902).

This genus is composed of less than a dozen species of small, modestly colored locusts. One of their distinguishing characters is the broad, flat, coarsely punctulate frontal costa.

32. **Coptacra succinea** Krauss.

Coptacra succinnea KRAUSS, Sitz. Acad. Wiss. Wien., Math.-Nat. Cl. LXXVI, (1), p. 34 (1877); KARSCH, Berlin Ent. Zeitschr., XXXVIII, p. 92 (1893).

The species is represented by two males and four females, bearing the label "Batanga, Kamerun, F. H. Hope, Coll., C. M. Acc. 5264" and two females with the label "Lolodorf, Kamerun, A. I. Good, Coll., C. M. Acc. 5293."

33. **Coptacra anguliflava** Karsch.

Coptacra anguliflava KARSCH, *l. c.*, p. 92 (1893).

Three male specimens of a second species of the genus *Coptacra* are referred to *anguliflava* Karsch. They were taken by F. H. Hope in March and April, 1914, at Batanga.

Genus CYPHOCERASTIS Karsch.

Cyphocerastis KARSCH, Berlin, Ent. Zeitschr., XXXVI, p. 181 (1891); BOLIVAR, Ann. Soc. Ent. France, LXX, p. 625 (1902); KIRBY, Syn. Cat. Orth., III, p. 471 (1910).

The representatives of the present genus are rather small or medium-sized locusts which seem to be confined to tropical Africa. Three species have been described thus far. Two additional forms are now added. They may be distinguished by the subjoined key.

KEY FOR SEPARATING THE SPECIES OF CYPHOCERASTIS.

A. Tegmina and wings fully developed, reaching the tip of the abdomen or apex of the hind femora. Wings with the disc usually cerulean.

b. General color of insect black, more or less conspicuously marked with yellow. Antennæ entirely black . . . . . *læta* Karsch.

bb. Color of insect more or less testaceous or olivaceous varied with black.

c. Posterior tibiæ and tarsi ferruginous, the femora subannulate with fuscous. Apex of antennæ white . . . . . *tristis* Karsch.

cc. Posterior tibiæ and tarsi variable, but not ferruginous. Antennæ not tipped with white.

d. Posterior femora externally longitudinally streaked with fuscous at middle. Hind tibiæ and tarsi fusco-testaceous. *clavareaui* Bolivar.

dd. Posterior femora internally and below blood-red, externally black, with six large conspicuous yellow maculations, two below and four above. Hind tibiæ almost black, with a dark grayish prebasal annulus. The tarsi tinged with vinaceous. Under side of the abdomen strongly tinged with red . . . . . *picturata* n. sp.

AA. Tegmina and wings somewhat abbreviated, considerably shorter than the abdomen in both sexes. Disc of hind wings dull ferruginous . . *hopei* n. sp.

34. **Cyphocerastis picturata** n. sp.

A medium-sized, dark, and rather highly colored insect, with the lower sulcus and inner face of the hind femora and lower side of the abdomen deep blood-red. The head, pronotum, pleura of metathorax, and upper edge and outer face of hind femora prominently marked with bright yellow. Wings cerulean with fuscous apex.

Head and thorax strongly and coarsely punctulate, the former about as wide as the front edge of the pronotum, the eyes rather prominent, fully twice as long as wide, separated above by a space a little less than the diameter of the basal antennal joint, the vertex rather deeply sulcate, and provided with a median and longitudinal carina of nearly equal prominence with the lateral ones, the fastigium a little depressed and broadly sulcate; frontal costa between the antennæ prominent and fully twice the width of the vertex or the diameter of the basal antennal joints, narrowing a little below the ocellus and fading towards the clypeus; lateral carinæ of the face parallel, moderately prominent throughout; antennæ black, filiform, a little longer than the head and pronotum combined, the subapical joints somewhat flattened and closely pitted. Pronotum provided with a prominent median carina; the three transverse sulci of nearly equal prominence, the anterior margin at middle gently rounded, the apex obtusely angled. Tegmina of moderate width, reaching the apex of the hind femora and tip of the abdomen. Hind femora rather robust basally, slender apically; the superior carina somewhat serrate; hind tibiæ slender, prominently hirsute, with ten spines on their outer margin and eleven internally. Prosternal spine short, acuminate; the mesosternal lobes widely separated, those of the metasternum narrowly so. Valves of the ovipositor elongate, slender, exserted, the apices rather strongly hooked.

General color above dull black, becoming fusco-olivaceous on the disc of the pronotum and dorsal portion of the closed tegmina and the abdomen above. Anterior and middle legs olivaceous; meso- and metasternum olivaceous, lower surface of the abdomen vinaceous red. Hind femora shining black, varied with bright yellow above and externally, below and on their inner face blood-red. Vertex, fastigium, a dot back of each eye and considerable portion of the face and cheeks below the eyes, bright lemon-yellow. Pronotum above at its sides in advance of the first transverse sulcus and behind the second sulcus to the hind margin prominently striped with yellow; the lateral lobes

are also varied with yellow, there being a prominent patch of this color both at the anterior and posterior lateral angles, as well as one on the pleura above the base of each hind femur.

Length of body, ♀, 24 mm.; of pronotum, 5.25 mm.; of tegmina, 18 mm.; of hind femora, 13 mm.; of hind tibiæ, 12 mm.

Habitat: The only specimen at hand, the type, comes from Lolodorf, where it was taken by A. I. Good. C. M. Acc. No. 5264.

35. **Cyphocerastis hopei** n. sp.

A little below medium in size. Tegmina and wings abbreviated, about two-thirds the length of the abdomen. Legs, front, occiput, upper part of the abdomen and dorsum of the pronotum and superior portion of the folded tegmina, olivaceous. Lower half of lateral lobes of the pronotum, cheeks below the eyes, and the pleura, banded with flavous; upper half of the sides of pronotum, anterior half of tegmina, and ventral part of the body, antennæ, and genicular portion of the hind femora, black; the hind tibiæ also black, hirsute, without basal or prebasal pale annulation.

Head and pronotum rather coarsely and closely punctulate; the former not prominent, about as wide as the front edge of the pronotum, the eyes prominent, one and one-half times as long as wide, separated at the vertex by a space about equal to the diameter of the first (♀) or second (♂) antennal joint, the vertex deeply sulcate, and provided with a median longitudinal carina which continues backwards across the occiput to its base; fastigium of the vertex a little depressed, sulcate, and punctulate, the frontal costa broad and also prominently punctulate, narrowing below the ocellus and continuous to the clypeus; lateral or facial carinæ broadly bowed outward at center, prominent, of equal prominence throughout. Antennæ a little heavy, extending one-third of their length beyond the hind margin of the pronotum. Latter gently divergent towards its base, the median carina coarse, somewhat interrupted by the punctures and transverse sulci; anterior margin at middle rounded and a little advanced upon the occiput, hind margin obtusangulate. Tegmina rather profusely and strongly veined and reticulate, their apex rounded. Anterior and middle legs slender, the femora, even in the male, but faintly incrassate; hind femora rather elongate, slender apically, the hind tibiæ lengthily hirsute, the outer margin provided with nine and the inner with ten or eleven spines. Mesosternal lobes widely separated in both sexes,

those on the metasternum nearly contiguous in the male, but somewhat distant in the female. Prosternal spine rather large at base, short, evenly pyramidal, the apex acuminate. Apex of male abdomen scarcely clavate, the last ventral segment short; supra-anal plate moderately large, the basal half with parallel sides and prominent lateral carinæ, the apical half separated from the basal by a strong transverse sulcus, tapering, and with the outer portion spatulate, the middle sulcate, the apophyses of the preceding segment fairly robust at base, bowed inward until they touch, the apical half slender and parallel, resting in the median longitudinal sulcus of the supra-anal plate which they fully occupy. Cerci of the male rather long, moderately robust and hirsute, directed upwards and bowed inwards for three-fifths of their length, from which point they are directed backwards and become smooth and more slender, their apices bluntly acuminate and extending beyond the tip of the last ventral segment.

Length of body, ♂, 17 mm., ♀, 20 mm.; of pronotum, ♂, 4 mm., ♀, 5 mm.; of tegmina, ♂, 8.5 mm., ♀, 10 mm.; of hind femora, ♂, 10 mm., ♀, 12 mm.

Habitat: Batanga. Two males and two females, taken by F. H. Hope. C. M. Acc. No. 5293. The types are in the Carnegie Museum.

Genus PTEROPERA Karsch.

Pteropera KARSCH, Berlin, Ent. Zeitschr., XXXVI, pp. 185, 189 (1891); KIRBY, Syn. Cat. Orth., III, p. 473 (1910).

The locusts included in this genus are medium-sized insects, with greatly abbreviated tegmina and without wings. They seem to be confined to the western coastal regions of tropical Africa. Three species have been previously described. A fourth is now added. The chief character of the genus seems to be the absence of a longitudinal sulcus on the exterior median field of the hind femora, the sulci and costæ of the area being arcuate and continuous. The various species may be separated as follows:

KEY TO THE SPECIES OF PTEROPERA.

A. Hind femora without dark markings. Pronotum lacking the lateral longitudinal piceous band . . . . . *uniformis* n. sp.

AA. Hind femora more or less varied with black or fuscous. Pronotum marked with a longitudinal dusky band along the upper field of its lateral lobes.

b. Smaller (♂, 21 mm.; ♀, 28 mm.). General color pale olivaceous

yellow. Hind tibiæ, except for a pale subbasal annulus, shining black.....*verrucigena* Karsch.

bb. Larger (♂, 22 mm.; ♀, 30 mm.). General color grayish or clay-yellow. Hind tibiæ not black.

c. Hind tibiæ griseo-testaceous.....*pictipes* Bolivar.

cc. Hind tibiæ blue at base, followed by a yellow annulus and beyond sanguineous.....*karschi* (Bolivar).

36. **Pteropera uniformis** n. sp.

As indicated by the synoptic key this insect is but slightly varied with dark markings, its general color being brunneo-olivaceous.

Head a little wider than the anterior margin of the pronotum. Eyes somewhat prominent, about one and one-half times as long as wide, and fully twice the length of the cheeks below them, separated above by a space about equal to the diameter of the basal antennal segment; the vertex depressed, sulcate, and provided with a more or less apparent median longitudinal carina which extends upon the occiput. Fastigium punctulate, not sulcate, roundly connected with the upper extremity of the frontal costa. Face a little oblique or receding, rugosely punctulate; the costa of nearly equal width throughout, but little sulcate at any point, continuous to the clypeus. Antennæ moderately slender, reaching to the apex of the mesonotum. Pronotum rather profoundly and rugosely punctulate, a little expanding to the rear, the three transverse sulci well marked, cutting or severing the median carina; anterior margin a little advanced upon the occiput, triangularly notched at its middle, the posterior margin almost straight and with the middle also triangularly notched or emarginate. Tegmina small, lateral, their tips rounded and reaching the tip of the metanotum. Legs about normal for the genus. Prosternal spine rather large, pyramidal, its apex a little blunt, gently directed to the rear. Valves of the ovipositor somewhat slender, their apices only gently hooked. General color brunneo-olivaceous, varied with only slight indications of the dusky markings mentioned for other species. Face, cheeks below the eyes, lower third of sides of pronotum and the metapleura pallid. Genicular portion of the hind femora and immediate base of the hind tibiæ pale testaceo-ferruginous. Antennæ pallid, not infuscated.

Length of body, ♀, 26 mm.; of pronotum, 5 mm.; of antennæ, 12 mm.; of tegmina, 5.15 mm.; of hind femora, 15 mm.

Habitat: Batanga, Cameroon, F. H. Hope, collector, two specimens, type and paratype. C. M. Acc. No. 5293.

Genus ORBILLUS Stål.

Orbillus STÅL, Recens, Orth., I, pp. 37, 71 (1873); IB., Bihang, Svensk. Akad. Handl., V (4), p. 29 (1878); BRUNNER, Ann. Mus. Genova, XXXIII, p. 144 (1893).

Orbillus is an African genus containing six known species. These insects are of average size and very probably have special food-habits and definite haunts.

37. **Orbillus cærulens** (Drury).

Gryllus cærulens DRURY, Ill. Nat. Hist., II, p. 79, pl. 42, fig. 1 (1773).
Locusta cærulea WESTWOOD, in Drury, Ill. Exot. Ent., II, p. 89, pl. 42, fig. 1 (1837).

Among the specimens from Batanga are two pairs of this species. They were collected in April, 1914, by F. H. Hope. C. M. Acc. No. 5293.

Genus CATANTOPS Schaum.

Catantops SCHAUM, Bericht. Akad. Berlin, 1853, p. 779; IB., Peters, Reise. n. Mossamb., Zoöl., V, p. 134 (1862); STÅL, Recens. Orth., I, pp. 37, 69 (1873); KARNY, Sitz. Akad. Wiss. Wien., Math.-Nat. Kl., CXVI, p. 309 (1907). For additional synonymy see Kirby, Syn. Cat. Orth., III, p. 476.

The genus *Catantops* is confined to the Old World with its center of abundance in Africa. Its members are, as a rule, medium-sized insects of modest coloration, though some of the species are brightly and strikingly colored. Kirby lists one hundred and three, and a supposedly additional species is described in this paper. Karny has given us a very comprehensive review of the genus in his article on "Die Orthopterenfauna des Ægyptischen Sudans," pp. 43–86. Apparently this genus is in the Old, what *Melanoplus* is in the New World, *i.e.*, the prevailing group of generally distributed common grasshoppers.

38. **Catantops mellitus** Karsch.

Catantops mellitus KARSCH, Berlin, Ent. Zeitschr., XXXVIII, pp. 94, 96 (1893); KARNY, Sitz. Akad. Wiss. Wien., Math.-Nat., Kl., CXVI, pp. 315, 335 (1907).

There are three specimens, one male and two females from Batanga, where they were collected by F. H. Hope. C. M. Acc. No. 5293.

39. **Catantops uniformis** n. sp.

A single male specimen of another species of the genus is before me. It seems to be new and in the arrangement of species belongs near

C. decoratus Gerstæcker, and *C. major* Karny. The specific name is suggested by its very uniform and rather pale rufo-testaceous color. While quite large, it is nevertheless moderately slender in its build, has the tegmina and wings decidedly longer than the abdomen and apex of the hind femora. The latter have their dorsal margin crossed by two dull fuscous patches and especially with a fairly prominent longitudinal stripe, which extends along the lower carina from the inner edge of the pale pre-apical annulus half-way to the base, from which point the greater portion of the inner face is infuscated; lower outer sulcus brunneous, the lower inner one more or less tinged with coral-red, genicular area strongly fuscous, all of the carinæ minutely nigro-punctate; hind tibiæ dull cinereous, the base with a well-defined paler annulus, the spines black on their outer half, ten in number on the outer and eleven on the inner margin. Hind wings vitreous, with dark veins and cross-veins, about twice as long as broad. Antennæ pallid, testaceous. Supra-anal plate elongate scutiform, the apex rather acuminate; cerci moderately slender, bowed upwards and inwards, the apical portion a little dilated and obliquely docked from below. Mesosternal lobes rather closely approaching, those of the metasternum touching.

Length of body, ♂, 33 mm.; of pronotum, 7 mm.; tegmina, 27 mm.; of hind femora, 17 mm.

Habitat: Banza Manteka, Belgian Congo (A. L. Bain, Collector). C. M. Acc. No. 4601.

40. **Catantops kraussi** Karny.

Catantops kraussi KARNY, *l. c.*, pp. 321, 345 (1907); KIRBY, Syn. Cat. Orth., III, p. 479 (1910).

Two males and three females of a third species of *Catantops* are referred to this species. They come from Batanga, and were collected by F. H. Hope. C. M. Acc. No. 5293.

41. **Catantops melanostictus** Schaum.

Cantantops melanostictus SCHAUM in Peters, Reise n. Mossamb., Zoöl., V, p. 134, pl. 7A, fig. 5 (1862); KARNY, *l. c.*, pp. 315, 336, pl. 2, figs. 16–20, pp. 350, 351 (1907). For additional synonymy see Kirby, *l. c.*, p. 480.

A single male specimen of this locust is at hand. It was collected by F. H. Hope at Batanga in April, 1914.

42. **Catantops mimulus** Karsch.

Catantops mimulus KARSCH, Berlin Ent. Zeitschr., XXXVI, p. 189 (1891); KARNY, *l. c.*, pp. 316, 336 (1907).

The collection contains a pair, male and female, of what appears to be *C. mimulus* Karsch. They were taken in April, 1914, by F. H. Hope. C. M. Acc. No. 5293.

43. **Catantops æsthmaticus** Karsch.

Catantops æsthmaticus KARSCH, Berlin Ent. Zeitschr., XXXVIII, pp. 95, 98, fig. 14 (1893); KARNY, *l. c.*, pp. 316, 336 (1907).

A single female specimen bearing the label "Congo (Antisdel), C. M. Acc. 2315" is referred to Karsch's *C. æsthmaticus*.

Genus STENOCROBYLUS Gerstæcker.

Stenocrobylus GERSTÆCKER, Arch. Naturg., XXXV, p. 219 (1869); IB., Von der Decken's Reise in Ost-Afrika, III (2), p. 45 (1873); STÅL, Bihang Svensk. Akad. Handl., V, no. 4, p. 29 (1878); KIRBY, Syn. Cat. Orth., III, p. 485 (1910).

This genus was erected to receive an insect related to representatives of the genus *Catantops*, but which differs in having remarkably abbreviated hind tibiæ, as well as in a few other respects. Since Gerstæcker described his *Stenocrobylus cervinus*, which was the type of the genus, seven others have been added. Now an eighth is described.

The annexed table may be of value in separating the species. It will be observed that among the species there is quite a range of variation in tibial length, spine-formulæ, and color-pattern.

SYNOPSIS OF THE SPECIES OF STENOCROBYLUS.

A. Insects rather plainly colored, not banded and maculate with bright yellow. Hind tibiæ noticeably shorter than the femora.

b. General color above rufous, below testaceous, or greenish.

c. Larger (♂, 24 mm.; ♀, 32 mm.). Habitat, Africa. *cervinus* Gerstæcker.

cc. Smaller (♂, ?; ♀, 20 mm.). Habitat, Southern India. *femoratus* Bolivar.

bb. General color above smoky black, below testaceous. Size (♂, ?; ♀, 32 mm.). Habitat, Angola, West Africa . . . . . *fumosus* Bolivar.

AA. Insect conspicuously streaked, mottled, and banded with yellow testaceous and black. Hind tibiæ variable as to length and the number of spines externally.

b. Less conspicuously marked. The prevailing color pale testaceo-

ferruginous, the pronotum, pleura, and hind femora marked with maculæ, lines, and bands of black. Wings pale rose, becoming flavous apically (♂, ?; ♀, 25 mm.). Habitat, Congo

roseus Giglio-Tos.

bb. More conspicuously colored or marked. The prevailing color variable, but the markings yellow.

c. Wings pale blue, the margins and apex somewhat infuscated. Size (♂, ?; ♀, 25 mm.). Habitat, Congo . . . . . *cyaneus* Bolivar.

cc. Wings variable, but never blue or bluish.

d. Wings smoky orange at base, becoming fuscous apically.

e. Smaller (♂, 21 mm.; ♀, 28 mm.). Head, pronotum, sides of meso- and meta-thorax and hind femora shining black, conspicuously mottled and banded with yellow. Geniculæ and hind tibiæ with tarsi carmine.

festivus Karsch.

ee. Larger (♂, 26 mm.; ♀, 32 mm.). Head, with front and cheeks anteriorly flavous, occiput and cheeks back of eyes, dorsum, middle of lateral lobes of pronotum, together with sides of meso- and metathorax and hind femora with two wide bands and apex black; the occiput at sides, the pronotum at sides of disc, and on lower edge, the pleura above the coxæ of median and posterior legs streaked with yellow, hind femora also conspicuously marked with yellow. Hind tibiæ fuscous.

catantopoides sp. nov.

dd. Wings more pallid, greenish, or amber.

e. Larger (♂, 28 mm.; ♀, ?). Disc of wings greenish. Antennæ very long . . . . . *antennatus* Bolivar.

ee. Smaller (♂, 21 mm.; ♀, 30 mm.). Disc of wings pale amber. Antennæ normal . . . . . *ornatus* Giglio-Tos.

44. **Stenocrobylus festivus** Karsch.

Stenocrobylus festivus KARSCH, Berlin. Ent. Zeitschr., XXXVI, p. 190 (1891); KIRBY, Syn. Cat. Orth., III, p. 485 (1910).

A. I. Good collected one male and two females of *S. festivus* at Lolodorf in August, 1913. C. M. Acc. No. 5264.

45. **Stenocrobylus catantopoides** n. sp.

Similar to *S. antennatus* Bolivar in color and markings, as well as in the unusual length of the antennæ, but considerably smaller, and having the general color above dark fuscous, instead of fuscous green. The present species also is noted for the nearly or quite normal length of the hind tibiæ with nine spines externally as in some of the representatives of the genus *Catantops*, hence the suggested specific name.

Head of moderate size, about as wide as the anterior portion of the pronotum, the occiput rounded and slightly ascending, comparatively short; eyes large and prominent, in both sexes somewhat longer than the anterior edge of the cheeks below them; vertex a little depressed, in the male as wide as the diameter of the second, and in the female as that of the first antennal joints, very narrowly and gently longitudinally sulcate, the fastigium of moderate size, subquadrate, about as long (♂) or not quite (♀) as wide, the disc flat, surrounded by coarse carinæ in continuation of those of the vertex; frontal costa a little wider than the vertex, prominent above between the antennæ, less so below the ocellus, punctulate, plain in the female, broadly and shallowly sulcate in the male, continuous to the clypeus, sulcate in both sexes at the ocellus and below. Antennæ rather robust, in the male nearly as long as the hind femora, in the female a little shorter. Pronotum strongly punctulate, on the hind lobe very closely so, anterior lobe with the sides parallel, the posterior one rather strongly divergent, median carina prominent on hind, less so on front lobe, thrice interrupted by the well-defined transverse sulci, anterior margin gently rounded, angulate behind. Tegmina and wings fully developed in both sexes, surpassing both the tip of the abdomen and the apex of the hind femora, rather profusely and heavily veined. Anterior and middle legs comparatively slender, even in the male; hind femora elongate, somewhat robust at base, with large geniculæ, the hind tibiæ elongate, the exterior margin nine-spined, interior margin ten-spined. Prosternal spine elongate, directed a little to the rear, large, coarse, its apex rounded; mesosternal lobes decidedly rounded internally, separated by a space a trifle wider than long, metasternal lobes also separated, but the space much narrower than that of the mesosternum. Male abdomen tapering, the apical segment acuminate, its apex entire; supra-anal plate elongate triangular, deeply sulcate at center to middle, tumid apically, and with a prominent transverse carina just back of the middle. Anal cerci not quite reaching the apex of the supra-anal plate, slender, bowed, directed to the rear and inwards, their apex a little flattened, blunt; valves of ovipositor elongate, curved, acuminate, not prominently toothed.

General color above dark fuscous, with a tinge of olive on the dorsum of the pronotum and dorsal field of tegmina and legs; front, abdomen, and underside flavous with a tinge of olive or green. Occiput at side, outer margins of the disc and lower margins of the pro-

notum, prominently streaked with yellow; meso- and meta-thorax obliquely streaked with the same color. Hind femora black, thrice banded with yellow, this latter color interrupted externally in the basal and median bands, so as to give a maculate appearance to this member; tibiæ fuscous, the base widely flavo-annulate; antennæ testaceous, a little darker apically.

Length of body, ♂, 26 mm., ♀, 28 mm.; of pronotum, ♂, 5.15 mm., ♀, 6.85 mm.; of tegmina, ♂, 20 mm., ♀, 27 mm.; of hind femora, ♂, 15 mm., ♀, 17 mm.; of hind tibiæ, ♂, 12 mm., ♀, 15 mm.

Habitat: Batanga, F. H. Hope, collector, taken in April, 1914. One male and one female, the types, are the only representatives of the species. C. M. Acc. No. 5293.

Genus EUPREPOCNEMIS Fieber.

Euprepocnemis FIEBER, Lotos, III, p. 98 (1853); IV, p. 178 (1854); IB., Syn. Eur. Orth., p. 9 (1854).

Euprepocnemis STÅL, Recens. Orth., I, p. 75 (1873), etc. (See Kirby, *l. c.*, p. 559.)

Africa seems to be the center of distribution for members of this genus, although it is represented over most of the Orient, extending even into some of the islands of the Pacific. Eighteen species are recognized in Kirby's Catalogue.

46. **Euprepocnemis plorans** (Charpentier).

Gryllus plorans CHARPENTIER, Hor. Ent., p. 134 (1825); RAMBUR, Faune Andal., II, p. 78 (1838). See synonymy in Kirby, Syn. Cat. Orth., III, p. 560.

Specimens of *E. plorans* are at hand from Lolodorf and Batanga. A male and two females were taken by A. I. Good at the former locality and a male by F. H. Hope at the latter.

Specimens of this species are in the collection of the writer from both China and Japan.

47. **Euprepocnemis guineënsis** Krauss.

Euprepocnemis guineënsis KRAUSS, Zoöl. Jahrb., Syst., V, p. 659, pl. 45, fig. 5 (1891).

Euprepocnemis guineënsis var. *maculosa* KRAUSS, *l. c.*, p. 660, pl. 45, figs. 6, 6A (1891).

I find a female specimen which is referable to *E. guineënsis* Krauss. It is from Lolodorf, where it was collected by A. I. Good. C. M. Acc. No. 5264.

Genus CALLIPTAMUS Serville.

Calliptamus SERVILLE, Ann. Sci. Nat., XXII, p. 282 (1831); IB., Hist. Orth., 686 (1839); FISCHER, Orth. Ross., pp. 228, 236 (1846); JACOBS & BIANCHI, Prem. i Lozhn. Ross. Imp., pp. 173, 204, 316 (1902); KIRBY, Syn. Cat. Orth., III, p. 551 (1910), for synonymy see Kirby, *l. c.*

This genus is confined to the Eastern Hemisphere, and contains several species, one or two of which at times are pests.

48. **Calliptamus italicus** (Linnæus).

Gryllus Locusta italicus LINNÆUS, Syst. Nat. (Ed. 10), I, p. 432 (1758). For a very full synonymy see Kirby, *l. c.*, pp. 551–553.

. There are two female specimens of this common, but very interesting locust at hand. They were collected by Dr. W. J. Holland in October, 1911, at Tangier, Morocco. C. M. Acc. No. 4514.

The specimens are in exceptionally fine condition both as to color and preservation.

Suborder *TETTIGONOIDEA*.

Family GRYLLACRIDÆ.

This family is made up of a number of forms, which for the most part lack the auditory openings on the anterior tibiæ, and are without stridulating apparatus in the males, in cases where this sex is provided with wings. Kirby lists sixteen genera in his Catalogue.

Genus GRYLLACRIS Serville.

Gryllacris SERVILLE, Ann. Sci. Nat., XXII, p. 138 (1831); IB., Hist. Nat. Ins. Orth., p. 392 (1839); BRUNNER VON WATTENWYL, Verh. Zoöl.-Bot. Ges. Wien., XXXVIII, pp. 316, 317 (1888), etc., etc.

This genus is composed of many species and is quite widely distributed over the surface of the earth, especially in tropical and subtropical regions, where these insects abound in moist, dark localities. They are nocturnal in their habits, and sometimes when on the wing are attracted to lights where they may be collected.

49. **Gryllacris quadripunctata** Brunner.

Gryllacris quadripunctata BRUNNER, Verh. Zoöl.-Bot. Ges. Wien, XXXVIII, p. 357 (1888); KIRBY, Syn. Cat. Orth., II, p. 145 (1906).

Two males of this genus taken by A. I. Good at Lolodorf in May, 1914, are referred to *G. quadripunctata* Brunner. C. M. Acc. No. 5264.

50. **Gryllacris africana** Brunner.

Gryllacris africana BRUNNER, *l. c.*, pp. 325, 362 (1888); KIRBY, *l. c.*, p. 147 (1906).

A pair, male and female, from Lolodorf, taken by A. I. Good in May, 1914, are referred to *G. africana* Brunner. C. M. Acc. No. 5264.

Family HETRODIDÆ.

The representatives of the family Hetrodidæ are remarkable in appearance. Many of them are ornamented with long spine-like projections on the disk and along the borders and lateral carinæ of the pronotum, while others have this part smooth. The group is native to the continent of Africa, to southern and southeastern Europe, and southwestern Asia. Fourteen genera have thus far been recognized and described by orthopterists, and fifty-seven species assigned to them.

51. **Cosmoderus** ? sp.?

A single very immature nymph is contained among the specimens collected by F. H. Hope at Batanga. It was taken in March, 1914. C. M. Acc. No. 5293. It seems to be referable to the genus *Cosmoderus* rather than to any other. It is chiefly deep shining black, with the anterior and median femora almost wholly, and the posterior ones on their apical two-fifths or one-half, pale testaceous. The median and posterior tibiæ are also largely tinged with this color, except at their base and apex. The antennæ are robust at base and slender apically, the basal ten joints are black, while those beyond are pallid. Both the disc of the pronotum and the dorsal portion of the abdominal segments are very conspicuously longitudinally carinated, giving the insect a peculiar corrugated appearance. Whether this individual is the young of one of the described species, or new, I cannot say.

Family PYCNOGASTERIDÆ.

This is also an Old World group of the Tettigonoidea and is confined chiefly to the Mediterranean region. These insects are wingless, or almost so, being provided with these appendages only in the form of stridulating organs almost covered by the pronotum, and present in both sexes. According to Kirby's Catalogue of the Orthoptera there are eighty-eight recognized species, distributed among eight genera.

Genus STEROPLEURUS Bolivar.

Steropleurus BOLIVAR, Bol. An. Soc. Esp. Hist. Nat., VII, p. 449 (1878); IB., Ann. Sci. Nat. Porto, V., pp. 133, 139 (1898); KIRBY, Syn. Cat. Orth., II, p. 163 (1906).

52. **Steropleurus siculus** (Fieber) (?)

A female specimen of *Steropleurus*, as limited by Bolivar, on comparison with keys and descriptions, appears to be closely related to, if not identical with, *S. siculus* (Fieber).

The specimen was collected by Dr. W. J. Holland at Tangier, Morocco, in October, 1911. C. M. Acc. No. 4514.

Family CONOCEPHALIDÆ.

Genus PSEUDORHYNCHUS Serville.

Pseudorhynchus SERVILLE, Ins. Orth., p. 509 (1839); REDTENBACHER, Verh. K. K. Zoöl.-Bot. Ges. Wien, XLI, pp. 329, 364 (1891); KARNY, Abh. K. K. Zoöl.-Bot. Ges. Wien, IV, pt. 3, p. 17 (1907).

Pseudorhynchus is entirely confined to the eastern hemisphere, and contains about a dozen and a half recognized species.

53. **Pseudorhynchus lanceolatus** (Fabricius).

Locusta lanceolatus FABRICIUS, Syst. Ent., p. 284 (1775).
Conocephalus lanceolatus BURMEISTER, Handb. Ent., II, p. 704 (1838).
Pyrgocorypha hastata BOLIVAR, Jorn. Sci. Lisboa, (2), I, p. 222 (1890).
Pseudorhynchus hastatus REDTENBACHER, *l. c.*, p. 336 (1891); KARNY, *l. c.*, p. 17 (1907).
Pseudorhynchus lanceolatus KIRBY, Syn. Cat. Orth., II, p. 238 (1906).

There are two males of this species. They are from Lolodorf, where they were taken by A. I. Good on October 1, 1913, and February 25, 1914, respectively.

Genus HOMOROCORYPHUS Karny.

Homorocoryphus KARNY, Abh. K. K. Zoöl.-Bot. Ges. Wien, IV, pt. 3, pp. 4, 41–50 (1907). This is in part *Conocephalus* of authors.

There are many distinct species of this genus known to entomologists. They occur in both hemispheres, and range through the tropics as well as the adjacent parts of the temperate zones. Between forty and fifty forms have been referred to the genus.

54. **Homorocoryphus nitidulus** (Scopoli).

Gryllus nitidulus SCOPOLI, Del. Flor. Faun. Insubr., I, p. 62, pl. 24*B* (1786); GRIFFINI, Boll. Mus. Zoöl. Anat. Comp. Torino, XI, no. 220, p. 1 (1896).

For the very extended synonymy of this species see Kirby, Syn. Cat. Orth., II, pp. 252–253. It was referred to *Homorocoryphus* by Karny, the author of the genus, *l. c.*, p. 44 (1907).

Six males, one female, and three nymphs are at hand from Batanga (F. H. Hope, Coll.) and two females from Lolodorf (A. I. Good, Coll.). Another female which varies somewhat from the others in length of wing and robustness of the hind tibiæ, is doubtfully referred to this species. It also is from Lolodorf, where it was taken by A. I. Good.

Family XIPHIDIIDÆ.

Genus ORCHELIMUM Serville.

Orchelimum SERVILLE, Ins. Orth., p. 522 (1839); SCUDDER, Guide N. A. Orth., p. 55 (1897); MCNEILL, Can. Ent., XXXII, p. 77 (1900); KIRBY, Syn. Cat. Orth., II, p. 271 (1906); KARNY, Abh. K. K. Zoöl.-Bot. Ges. Wien, IV, (3), p. 81 (1901).

Xiphidium subg. *Orchelimum* REDTENBACHER, Verh. K. K. Zoöl.-Bot. Ges. Wien, XLI, p. 494 (1891), for further references see Kirby, *l. c.*

The members of the present genus, with the exception of a single species, belong to North America and adjacent islands.

55. **Orchelimum senegalense** Krauss.

Orchelimum senegalense KRAUSS, Sitz. Akad. Wien, Math.-Nat. Cl., LXXVI (1), p. 60, pl. 1, fig. 12 (1877); KIRBY, *l. c.*, p. 274 (1906); KARNY, *l. c.*, p. 84 (1901).

Xiphidium senegalense REDTENBACHER, Verh. K. K. Zoöl.-Bot. Ges. Wien, XLI, pp. 495, 504 (1891); SJÖSTEDT, Bih. Svenska Akad., XXVII (4: 3), p. 140 (1902).

Four females, three males, and one nymph of this insect are among the material collected by F. H. Hope at Batanga. They were taken in March and April, 1914. C. M. Acc. No. 5293.

Genus XIPHIDION Serville. (Conocephalus)

Xiphidion SERVILLE, Ann. Sci. Nat., XXII, p. 159 (1831); IB., Ins. Orth., p. 505 (1838); BLANCHARD, Hist. Nat. Ins., III, 25 (1840); REHN, (1902); KARNY, (1907), etc.

For an extended synonymy see Kirby, Syn. Cat. Orth., p. 274.

The genus *Xiphidion* contains many representatives, upwards of

eighty species now being recognized. These are found scattered in various regions of the Earth. They are, for the most part, frequenters of grass-lands, such as prairies, meadows, swampy tracts on the margins of streams, ponds, lakes, etc., as well as in grassy clearings. A few are restricted to certain types of localities and certain grasses, while others are widely scattered.

Several species are recognized among the material now receiving attention.

56. **Xiphidion neglectum** sp. nov.

A single male of a species, which does not run to any of the described forms given in either Redtenbacher's or Karny's synoptic keys, is at hand. If we accept the statement that the hind margins of the lateral lobes of the pronotum are rounded, it will not run; if we decide that the hind margins are straight or nearly so, we find the same trouble. It belongs to the series having the anterior tibiæ five- to seven-spined below; the cerci are slender, acuminate, and do not have the apex depressed or flattened and are provided with a single inner tooth near the middle, the dorsum of abdomen is not definitely infuscated, the fastigium is rather wide at its apex with the lateral margins divergent, the hind femora are unarmed, the tegmina are as long as the wings and surpass the apex of the hind femora, the fastigium, occiput, and the disc of the pronotum are visibly longitudinally marked with ferruginous and the disc of the tegmina also shows signs of infuscation. Otherwise the entire insect is uniformly pale testaceous, it very evidently having been left in the wet cyanide tube for a day or two thus causing it to loose any possible characteristic colorations.

Length of body, ♂, 15 mm.; of tegmina, 16 mm.; of hind femora, 12 mm.

Habitat: Batanga (F. H. Hope, Collector). Taken in April, 1914. C. M. Acc. No. 5293.

57. **Xiphidion continuum** Walker.

Xiphidium continuum WALKER, Cat. Derm. Salt. Brit. Mus., II, p. 271 (1869).
Anisoptera continuum KIRBY, Syn. Cat. Orth., II, p. 279 (1906).

A pair, male and female, of a second species are determined as *X. continuum* Walker. They are from Batanga, and were collected by F. H. Hope in April. C. M. Acc. No. 5293.

58. **Xiphidion iris** Serville.

Xiphidion iris SERVILLE, Ins. Orth., p. 506 (1839); KARNY, Abh. K. K. Zoöl.-Bot. Ges. Wien, IV, pt. 3, p. 94 (1907). For further synonymy see Kirby, *l. c.*, p 279.

Batanga, one male and one female. F. H. Hope, collector.

59. **Xiphidion africanum** Redtenbacher.

Xiphidium africanum REDTENBACHER, Verh. K. K. Zoöl.-Bot. Ges. Wien, XLI, pp. 497, 516 (1891).
Xiphidion africanum KARNY, *l. c.*, p. 94 (1907).
Anisoptera africanum KIRBY, *l. c.*, p. 279.

A single female of this species, from Batanga, taken in March, 1914, by F. H. Hope.

60. **Xiphidion guineënse** Redtenbacher.

Xiphidium guineënse REDTENBACHER, *l. c.*, pp. 497, 518 (1891).
Xiphidion guineënse KARNY, *l. c.*, p. 94 (1907).
Anisoptera guineënse KIRBY, *l. c.*, p. 280 (1906).

There are three males and three females collected by F. H. Hope in April, 1914, at Batanga.

This and the preceding species are very similar, except as to length of wing.

61. **Xiphidion obtectum** Karny.

Xiphidion obtectum KARNY, *l. c.*, pp. 94, 96 (1907).

This species of *Xiphidion* is represented by twenty-one males and eight females, from Batanga, collected by F. H. Hope.

62. **Xiphidion conocephalus** Linnæus.

Gryllus Tettigonia conocephalus LINNÆUS, Syst. Nat. (Ed. XII), I, (2), p. 696 (1767). For a synonymy of this species see Kirby, *l. c.*, p. 279.

Eleven representatives of a seventh species of *Xiphidion* coming from western Africa are referred to *æthiopicum* Thunberg, and, if Kirby is correct in his surmise as to synonymy, they are the same as *conocephalus* Linnæus. There are three males and eight females taken by F. H. Hope at Batanga.

Family PSEUDOPHYLLIDÆ.

Genus OPISTHODICRUS Karsch.

Opisthodicrus KARSCH, Ent. Nachr., XVI, p. 272 (1890); IB., Berlin. Ent. Zeitschr., XXXVI, pp. 76, 86 (1891); BRUNNER VON WATTENWYL, Mon. Pseudoph., pp. 9, 31 (1895); KIRBY, Syn. Cat. Orth., II, p. 292 (1906).

63. **Opisthodichrus cochlearistylus** Karsch.

Opisthodichrus cochlearistylus KARSCH, Berlin. Ent. Zeitschr., XXXVI, p. 87, pl. 2, fig. 4 (1891); BRUNNER, *l. c.*, p. 32, pl. 1, fig. 3 (1895).

A male from Lolodorf and a female from Batanga are referred to this species. The former was collected by A. I. Good and the latter by F. H. Hope. C. M. Acc. Nos. 5264 and 5293.

Genus LIOCENTRUM Karsch.

Liocentrum KARSCH, *l. c.*, p. 272 (1890).

This is an African genus based on a species found in Cameroon.

64. **Liocentrum aduncum** Karsch?

Liocentrum aduncum KARSCH, Berlin, Ent. Zeitschr., XXXVI, p. 88, pl. 2, fig. 3 (1891); BRUNNER, *l. c.*, p. 32 (1895).

A female Pseudophyllid from Lolodorf is referred to Karsch's *Liocentrum aduncum* with some misgivings. It apparently has been immersed in spirits, has lost its color, and its wings have also become somewhat distorted. It was taken February 19, 1914, by A. I. Good. C. M. Acc. No. 5264.

Genus CYMATOMERA Schaum.

Cymatomera SCHAUM, Ber. Akad. Berlin, 1853, p. 777; IB., in Peter's Reise n. Mossamb., V, p. 122 (1862); STÅL, Recens. Orth., II, pp. 53, 69 (1874); KARSCH, Ent. Nachr., XVI, p. 274 (1890); IB., Berlin. Ent. Zeitschr., XXXVI, pp. 77, 96 (1891); BRUNNER, Mon. Pseudoph., pp. 12, 82 (1895).

This is also an African genus, which contains several species. From the general griseous color of its representatives I should judge them to be dwellers on tree-trunks or on the ground among various kinds of dead and decaying vegetation, or perhaps on lichen-covered rocks. Only one species is at hand.

65. **Cymatomera argillata** Karsch.

Cymatomera argillata KARSCH, *l. c.*, pp. 97, 98, pl. 3, fig. 10 (1891); BRUNNER, *l. c.*, pp. 83, 85 (1895).

A single female from Batanga. It was collected in April by F. H. Hope. C. M. Acc. No. 5293.

Genus MORMOTUS Karsch.

Mormotus KARSCH, Ent. Nachr., XVI, pp. 269, 276 (1890); IB., Berlin. Ent. Zeitschr., XXXVI, p. 109 (1891); BRUNNER, Mon. Pseudoph., pp. 17, 153 (1895).

Mormotus is still another Pseudophyllid genus, all the described species of which are confined to tropical Africa. Eight species are known.

66. **Mormotus montesi** Bolivar.

Platyphyllum montesi BOLIVAR, An. Soc. Espan., XV, p. 347 (1886).
Mormotus obtusatus BRUNNER, *l. c.*, pp. 154, 155 (1895).
Mormotus montesi KIRBY, Syn. Cat. Orth., II, p. 323 (1906).

A female specimen from Lolodorf, is placed here. It was collected by A. I. Good. C. M. Acc. No. 5264.

Genus HOPLIDOSTYLUS Karsch.

Hoplidostylus KARSCH, Berlin. Ent. Zeitschr., XXXVIII, pp. 136, 138 (1893); BRUNNER, Mon. Pseudoph., pp. 17, 157 (1895).

The present genus contains only a single species, so far as known.

67. **Hoplidostylus argillatus** Karsch.

Hoplidostylus argillatus KARSCH, *l. c.*, p. 138, fig. 20 (1893); BRUNNER, *l. c.*, p. 158 (1895).

The species is represented by a single somewhat mutilated female from Banza Manteka in the Belgian Congo. It was collected by A. L. Bain. C. M. Acc. No. 4601. A second specimen, also a female, with excessively long antennæ, from Lolodorf is also doubtfully placed in this species, although it does not quite agree with the diagnosis as given by Brunner v. Wattenwyl in his Monograph of the Pseudophyllidæ. The specimen was collected by A. I. Good. C. M. Acc. No. 5264.

Family MECOPODIDÆ.

The *Mecopodidæ* are one of the tropical families of long-horned grasshoppers, which are fairly well represented in Africa. The family contains some remarkably bizarre forms. Practically all of these insects are obscurely colored, and evidently spend the greater part of their lives on or near the ground among fallen leaves and other dead and decaying vegetation.

Genus ACRIDOXENA White.

Acridoxena WHITE, Proc. Roy. Phys. Soc. Edinb., III, p. 309 (1865); REDTENBACHER, Verh. K. K. Zoöl.-Bot. Ges. Wien, XLII, pp. 190, 208 (1892); KIRBY, Syn. Cat. Orth., II, p. 362 (1906). For synonymy see Kirby, *l. c.*

68. **Acridoxena hewaniana** Smith.

Acridoxena hewaniana SMITH, Proc. R. Phys. Soc. Edinb., III, p. 311 (1865); KIRBY, Trans. Ent. Soc. London, 1891, p. 410; REDTENBACHER, *l. c.*, p. 209 (1892).

Stalia fodiata SCUDDER, Proc. Bost. Soc. Nat. Hist., XVII, pp. 456, 457, figs. 3–5 (1875).

Eustalia foliata SCUDDER, *l. c.*, XX, p. 95 (1879); KARSCH, Ent. Nachr. XII, pp. 145–147, fig. (1886).

This bizarre insect is represented by a fine female specimen from Lolodorf collected by A. I. Good. C. M. Acc. No. 5264.

Genus ELUMA gen. nov.

This generic name is proposed for an insect from the Congo, which is related to the species of *Anœdopoda* Karsch, but without the vitreous spots along the disc of the tegmina. By running it in Karsch's synoptic key of the Mecopodid genera it readily falls into the section 7.7. under 3.3. of 1.1. Since its elytra are long and ample, by a modification or extension of the key we would have the following:

8.8 Elytra elongate, greatly surpassing the hind femora.

9. Pronotal carinæ blunt, rounded, smooth. Venation of the elytra very regular, the transverse veins of the disc twenty-one or twenty-two in number ..... *Eluma* gen. nov.

9.9 Pronotal carinæ rather sharp and somewhat crenulate, or even toothed. Venation of the elytra less regular, the transverse veins of the disc eleven to fourteen in number ..... *Anœdopoda* Karsch.

69. **Eluma amplipennis** sp. nov.

Rather large, but somewhat graceful or slender, with long broad wings. Dark grayish brown, with scarcely any mottling or spotting with fuscous, except along the margins of the tegmina. The veins, cross-veins, and veinlets fuscous. Head a little narrower than the front end of the pronotum, smooth, provided with punctures in front and on the anterior part of the cheeks; the fastigium of the vertex broad, its apex widely rounded, much as in members of the next genus. Disc of the pronotum flat, comparatively smooth, or free from large

rugosities, evenly widening from front to base, twice furrowed by the two transverse sulci, which sever the lateral carinæ, posterior margin broadly rounded, the disc of the hind lobe showing traces of several longitudinal rugæ and blunt tubercles. Tegmina elongate, their apex greatly passing the apex of the slender hind femora, their length almost three and one-half times their greatest width. Legs elongate, rather slender, the hind femora at their base only gently robust, few-spined below, internally about six-spined, externally three- to four-spined. Ovipositor rather slender, evenly tapering, and gently falcate. Base of tegmina of female provided with a well defined stridulating area, that on the right elytron thin, pallid, membranous and free from veins; on the left heavy, dusky, and roughened.

Length of body, ♀, 45 mm.; of pronotum, 10 mm.; of tegmina, 60 mm.; width 17 mm.; length of anterior femora, 14 mm.; middle, 17 mm.; hind, 36.5 mm.

Habitat: The only specimen at hand, the type, which belongs to the Carnegie Museum, comes from Banza Manteka, in the Belgian Congo, where it was taken by A. L. Bain. C. M. Acc. No. 4601.

Genus ANŒDOPODA Karsch.

Anœdopoda KARSCH, Berlin. Ent. Zeitschr., XXXVI, pp. 333, 346 (1891); REDTENBACHER, Verh. K. K. Zoöl.-Bot. Ges. Wien, XLII, pp. 190, 210 (1892).

The members of this strictly African genus are very similar in general appearance to those belonging to the typical genus *Mecopoda*, which has a distribution extending to India, China, Japan, the Indo-Malayan Archipelago, and many of the larger "South-Sea" islands. The main difference between the species of the two genera is in the rather slender basal portion of the hind femora of representatives of this genus, when compared with the very robust basal portion of these members in *Mecopoda*.

70. **Anœdopoda erosa** Karsch.

Anœdopoda KARSCH, *l. c.*, XXXVI, pp. 334, 335, fig. 7 (1892); IB., XXXVIII, pp. 76, 77 (fig. 3) (1892).

One male and two females of this species are among the material collected by A. I. Good at Lolodorf. C. M. Acc. No. 5264.

Genus EUTHYPODA Karsch.

Euthypoda KARSCH, Berlin. Ent. Zeitschr., XXX, pp. 108, 111 (1886).

Macroscirtus PICTET, Mém. Soc. Génève, XXX, (6), p. 13 (1888); REDTENBACHER, Verh. K. K. Zoöl.-Bot. Ges. Wien, XLII, pp. 191, 216 (1892).

The present genus is solely African in its distribution. Four species are known. They are characterized by having excessively heavy and long hind femora.

71. **Euthypoda kanguroo** (Pictet).

Macroscirtus kanguroo PICTET, *l. c.*, p. 14, pl. 2, figs. 38, 38*a* (1888); REDTENBACHER, *l. c.*, pp. 217, 218 (1892).

The only specimen of this species in the collection, a female, was taken by A. I. Good at Lolodorf in November, 1913. C. M. Acc. No. 5264.

Genus CORYCUS Saussure.

Corycus SAUSSURE, An. Soc. Ent. France, (4), i, p. 487 (1861); KRAUSS, Zoöl. Jahrb., Syst., V, pp. 344, 349 (1890); KARSCH, Berlin. Ent. Zeitschr., XXXVI, pp. 335, 346 (1891); REDTENBACHER, Verh. K. K. Zoöl.-Bot. Ges. Wien, XLII, pp. 191, 220 (1892).

Like the two preceding genera this is also a strictly African genus, with its center of distribution about the Gulf of Guinea. Nine species are recognized according to Kirby's Catalogue. They may be separated as follows:

SYNOPSIS OF THE SPECIES OF CORYCUS.

A. Anterior tibiæ above plane, not sulcate; subbasally sometimes marked with black.

b. Pronotum with the posterior margin subangulate. Tegmina of male wider apically (32 mm.); the stridulating area rather simple, with few veins . . . . . *jourinei* Saussure.

bb. Pronotum with its posterior margin obtusangulate. Tegmina of male narrower apically (28 mm.); the stridulating area more complicated, provided with several heavy veins . . . . . *kraussi* Kirby.

AA. Anterior tibiæ above sulcate.

b. Anterior tibiæ near their base never marked with a black patch. *intermedius* Redtenbacher.

bb. Anterior tibiæ immaculate near their base.

c. Anterior tibiæ above less profoundly sulcate.

d. Posterior margin of the tegmina oblique, angulate above between the internal and posterior margins.

e. Tegmina between the internal and posterior margins obtusely angulate . . . . . *abruptus* Krauss.

ee. Tegmina between the internal and posterior margins acutely angulate . . . . . *karschi* Krauss.

dd. Posterior margin of the tegmina straight, above between the internal and posterior margins irregularly emarginate. *præmorsus* Krauss.

cc. Anterior tibiæ above profoundly or deeply sulcate.
d. Island of St. Thomé, Gulf of Guinea.
greeffi Krauss, *paradoxus* Bolivar.
dd. Gaboon, French Congo.....*siccifolium* Sjöstedt.

72. **Corycus kraussi** Kirby.

Corycus kraussi KIRBY, Syn. Cat. Orth., II, 367 (1906).
Corycus jourinei KRAUSS (*nec* Saussure), Zoöl. Jahrb., Syst., V, pp. 352, pl. 30, figs. 1*a*, *b* (1890); REDTENBACHER, *l. c.*, p. 221 (1892).

This species is represented by a single fine male, from Batanga. It was collected in April, 1914, by F. H. Hope. C. M. Acc. No. 5264.

Family MECONEMIDÆ.

The family Meconemidæ is comparatively small. Its representatives are all confined to the Old World. Eight genera are included in the family, comprising twenty-three species.

Genus AMYTTA Karsch.

Amytta KARSCH, Wien. Ent. Zeit., VII, p. 160 (1888); IB., Ent. Nach., XVI, p. 264 (1890); KIRBY, Syn. Cat. Orth., II, p. 373 (1906).

Only three species of this genus are known. All are native to tropical Africa.

73. **Amytta occidentalis** Karsch.

Amytta occidentalis KARSCH, Ent. Nachr., XVI, 264 (1890); GRIFFINI, Ann. Mus. Genova, XLII, p. 367 (1906); KIRBY, *l. c.*, p. 373 (1906).

This delicate insect is represented by a single male which was taken by A. I. Good at Lolodorf, May 27, 1914. C. M. Acc. No. 5264.

Family PHANEROPTERIDÆ.

The family known among orthopterologists by the above name is very extensive indeed, and, as stated in a former paper by the present author, (See ANNALS, Vol. IX, p. 286) "is distributed throughout the warmer countries of the globe, where its representatives are among the commoner and more conspicuous orthopterous insects to be met with at almost every turn." While that applied to conditions in America, the same remark is equally true of Africa, and, for that matter, of any other country, including the larger islands of the Orient. Most of these insects are green or greenish in color, and live

among the rank vegetation common in humid localities. Even many of the more arid tracts also have their characteristic representatives of the family. Many of the species are attracted to bright lights after nightfall, hence are quite readily collected. Others may be taken by beating and sweeping the foliage of trees and the herbage growing at the borders of forests, groves, thickets, and the margins of lakes and streams. Still others live upon the trunks of trees, on ledges of rocks, and the ground, mimicking their surroundings in color. At least fifteen distinct species of this family are represented in the material now at hand, upon which I am reporting.

Genus ARANTIA Stål.

Arantia STÅL, Recens. Orth., II, pp. 10, 25 (1875); BRUNNER VON WATTENWYL, Mon. Phan., pp. 17, 136 (1878); IB., Verh. K. K. Zoöl.-Bot. Ges. Wien, XLI, pp. 8, 63 (1891); KARSCH, Berlin. Ent. Zeitschr., XXXIII, pp. 422, 432 (1888).

The genus *Arantia* is composed of twenty or more species of rather large and showy insects, all of which are confined to Africa. While bearing a general resemblance to certain of the larger and more robust American forms, these insects possess certain distinctive characters of their own, which readily separate the two groups. Only three of the species are contained among the material at hand.

74. **Arantia rectifolia** Brunner?

Arantia rectifolia BRUNNER, *l. c.*, p. 137 (1878); KARSCH, *l. c.*, p. 433 (1888).

Two of the "katydids" among the material studied are referred to Brunner's *A. rectifolia* with some hesitation. They are both females. One of them come from Lolodorf, where it was taken by A. I. Good. C. M. Acc. No. 5264. The other is from the Belgian Congo, collected by Antisdel. C. M. Acc. No. 2315.

75. **Arantia orthocnemis** Karsch.

Arantia orthocnemis KARSCH, Ent. Nachr., XVI, p. 357 (1890).

A single male from Lolodorf is assigned to *A. orthocnemis* Karsch. It was taken by A. I. Good in August, 1913.

76. **Arantia mammisignum** Karsch.

Arantia mammisignum KARSCH, Stettin. Ent. Zeit., LVII, p. 332 (1896).

There is a single female specimen of this large and attractive species at hand. It also was captured by A. I. Good at Lolodorf. C. M. Acc. No. 5264.

Genus PHLAUROCENTRUM Karsch.

Phlaurocentrum KARSCH, Berlin. Ent. Zeitschr., XXXII, p. 445 (1888); BRUNNER, Verh. K. K. Zoöl.-Bot. Ges. Wien, XLI, pp. 11, 106 (1891).

The representatives of this African genus somewhat resemble those of the American genus *Scudderia*, although they are not closely related. Only three species have been recognized, all of them belonging to the general region from which the present collection comes.

77. **Phlaurocentrum latevittatum** Karsch.

Phlaurocentrum latevittatum KARSCH, *l. c.*, p. 446 (1888); IB., XXXVI, pp. 321, 322, fig. 1*a* (1891); BRUNNER, *l. c.*, p. 106 (1891).

The single representative of the species *P. lativittatum*, is a male from Lolodorf, where it was taken by A. I. Good.

Genus ZEUNERIA Karsch.

Zeuneria KARSCH, Berlin. Ent. Zeitschr., XXXII, p. 443 (1888); BRUNNER, *l. c.*, pp. 13, 94 (1891).

This genus which is monotypic is African.

78. **Zeuneria melanopeza** Karsch.

Zeuneria KARSCH, *l. c.*, p. 443 (1888).

One male from Lolodorf, A. I. Good, collector. C. M. Acc. No. 5364.

Genus PHANEROPTERA Serville.

Phaneroptera SERVILLE, Ann. Sci. Nat., XXII, p. 158 (1831). For the synonymy of this genus see Kirby, Syn. Cat. Orth., II, p. 434 (1906).

This, the typical genus of the family, is composed of approximately two dozen recognized species, which in their distribution are confined to the Old World. A single species, *nana*, has been recorded from South America, where it undoubtedly was accidentally introduced by means of commerce. All of the species are small, and quite similar in their general appearance. Four of them are contained in the material upon which I am reporting.

79. **Phaneroptera nana** Fieber.

Phaneroptera nana FIEBER, Lotus, III, p. 173 (1853). For further synonymy see Kirby, *l. c.*, p. 435 (1906).

This rather widely distributed and common species is represented

by a single female from Lolodorf, A. I. Good, Collector, and by eight males and fourteen females from Batanga, F. H. Hope, Collector.

80. **Phaneroptera reticulata** Brunner.

Phaneroptera reticulata BRUNNER, Mon. Phan., pp. 210, 213 (1878).

Although *reticulata* was described from South Africa, there are four individuals one male and three females, at hand from Batanga, thus considerably extending the range of the species. The material was taken by F. H. Hope. C. M. Acc. No. 5293.

81. **Phaneroptera** sp.?

There are three females of a third species of the genus before me. They are quite noticeably larger than either of the preceding, but, being somewhat discolored, are not readily determinable. This is particularly true, since the published synoptical keys are based largely on the males. One of the specimens comes from Lolodorf, A. I. Good, Collector, and the others from Batanga, F. H. Hope, Collector.

82. **Phaneroptera** sp.?

Still a fourth species of the genus *Phaneroptera* is represented by a single female specimen. It, too, is considerably discolored and difficult to determine for the same reason stated in connection with the preceding. This latter form is rather larger, and has broader tegmina and wings, than the three preceding and as yet is undetermined. Possibly it may be new. It comes from Batanga, where it was collected in April, 1914, by F. H. Hope. C. M. Acc. No. 5263.

Genus GELATOPŒA Brunner.

Gelatopœa BRUNNER, Verh. K. K. Zoöl.-Bot. Ges. Wien, XLI, pp. 15, 111 (1891); KARSCH, Stettin. Ent. Zeit., LVII, 343 (1896).

The genus *Gelatopœa* is African, and thus far contains but a single representative, which in general appearance seems very much like the Central and South American representatives of *Aphidnia*. These latter live largely on trunks of trees, stony ledges, and other places where lichens abound, and on account of their slow movements and variegated colors are well protected from their enemies.

83. **Gelatopœa bicolor** Brunner.

Gelatopœa bicolor BRUNNER, *l. c.*, p. 12, pl. 2, fig. 19 (1891); KIRBY, Syn. Cat. Orth., II, p. 439 (1906).

Only a single specimen of each of the two sexes of this interesting insect are at hand. They were collected by A. I. Good at Lolodorf. The male was taken in May, 1914, and the female in October, 1913. C. M. Acc. No. 5264.

Genus EURYCORYPHA Stål.

Eurycorypha STÅL, Œfv. Vet.-Akad. Förh., XXX (4), p. 40 (1873); IB., Recens. Orth., II, p. 18 (1874); BRUNNER, Mon. Phan., pp. 27, 272 (1878); IB., Verh. K. K. Zoöl.-Bot. Ges. Wien, XLI, pp. 19, 136 (1891); KARSCH, Berlin, Ent. Zeitschr., XXXVI, p. 425 (1888).

Still another common African genus of the family Phaneropteridæ is known as *Eurycorypha*. These insects are mostly above medium in size and recall such American genera as *Phylloptera* and *Microcentrum*. Twenty species are listed by Kirby in his Synonymic Catalogue of the Orthoptera. There seems to be an additional one at hand, at least it does not agree with any hitherto described species.

84. **Eurycorypha æquatorialis** Krauss?

Eurycoryphus æquatorialis KRAUSS, Zoöl. Jahrb., Syst., V, p. 663, pl. 45, fig. 9 (1890).

A single female of what appears to be this species is at hand. It comes from Lolodorf, where it was taken in November, 1913, by A. I. Good. C. M. Acc. No. 5264.

85. **Eurycorypha cereris** (Stål)?

Phylloptera cereris STÅL, Œfv. Vet.-Akad. Forh., XIII, p. 170 (1856).

Eurycorypha cereris STÅL, *l. c.*, XXX (4), p. 4 (1873); IB., Recens. Orth., II, p. 39 (1874); BRUNNER, Mon. Phan., pp. 272, 273 (1878); IB., Verh. K. K. Zoöl.-Bot. Ges. Wien, XLI, p. 136 (1891).

Another species, also represented by a single female, belonging to the genus *Eurycorypha* is referred with some doubt to *E. cereris* of Stål. It bears a resemblance to both *brevicollis* Stål, and *securifera* Brunner. The specimen was taken by Good at Lolodorf, Dec. 29, 1913. C. M. Acc. No. 5264.

The characters employed by Brunner in his Synoptical key are based principally on the males, hence the doubtful reference of the specimens now at hand, which all belong to the other sex.

86. **Eurycorypha zebrata** sp. nov.

Above the average in size, pale green with the tegmina transversely banded and streaked with brown. Tegmina broad, widest at middle, subtriangular in form.

Head rather large, as broad as the front end of the pronotum; the vertex broad, about as wide as four times the diameter of the basal antennal joint, separated from the front by a delicate straight transverse sulcus, extending across from the middle of the antennal cavities. Antennæ very slender, filiform, with their basal joint touching the inner edge of the lower third of the small elongate eyes. Pronotum rather large, about one and one-half times as long as wide, the disc flat, a very little divergent caudad, crossed by a single transverse sulcus at about one-third its length from the apex, middle longitudinally narrowly sulcate, instead of carinate; lateral carinæ straight, blunt; lateral lobes perpendicular, fully as high as long; anterior margin of the disc widely subangulately emarginate, posterior margin evenly and broadly rounded; upper posterior margin of the lateral lobes separated from hind lobe of the disc by a deep acute emargination over the insertion of the tegmina. Legs comparatively short and slender, the hind femora somewhat shorter than the greatest width of the tegmina, the carinæ of lower edge armed with several small spines on their apical two-fifths. Ovipositor rather large and broad, the margins smooth; last ventral segment or subanal plate triangular, acuminate, longitudinally bicarinate at middle. Lateral angles of disc of the pronotum and base of the tegmina fusco-brunneous.

Length of body, ♀, 30 mm.; of pronotum, 7.5 mm.; of tegmina, 43 mm.; greatest width of latter, 18 mm.; length of hind femora, 17 mm.

Habitat: The type, and only specimen at hand, comes from Lolodorf, where it was taken October 29, 1913, by A. I. Good. C. M. Acc. No. 5264.

Genus VOSSIA Brunner.

Vossia BRUNNER, Verh. K. K. Zoöl.-Bot. Ges. Wien, XLI, pp. 19, 139 (1891).

A West African genus with two species. These insects are noted for the very great depth of the lateral lobes of the pronotum, the posterior angles of which are subangulate.

87. **Vossia obesa** Brunner.

Vossia obesea BRUNNER, *l. c.*, p. 140, pl. 2, fig. 27 (1891); KIRBY, Syn. Cat. Orth., II, p. 464 (1906).

The collection made by A. I. Good at Lolodorf contains a single male, which is placed here. It was taken July 25, 1913. C. M. Acc. No. 5264.

Genus CORYCOMIMA Karsch.

Corycomima KARSCH, Stett. Ent. Zeitschr., LVII, p. 343 (1896).

This is still another genus, which is peculiar to the African tropics. It is also monotypic, so far as at present known.

88. **Corycomima flavescens** (Walker)?

Orophus flavescens WALKER, Cat. Derm. Salt. Brit. Mus., II, p. 386 (1869).
Plangia camerata KARSCH, Berlin. Ent. Zeitschr., XXXII, p. 457 (1888); BRUNNER, Verh. K. K. Zoöl.-Bot. Ges. Wien, XLI, pp. 137, 138 (1891).
Corycomima camerata KARSCH, Stett. Ent. Zeitschr., LVII, 344 (1896).

The only representative of the species and genus at hand comes from Lolodorf. It was collected by A. I. Good, October 1, 1913. C. M. Acc. No. 5264.

Suborder GRYLLOTALPOIDEA.

Among the saltatorial orthoptera none are more interesting than the insects known as "mole crickets." These, on account of their structure and burrowing habits, differ quite remarkably from their allies, the true crickets. Mole-crickets on account of their aquatic, or subaquatic, habits are confined to humid regions, where they may be obtained by digging for them at the margins of streams and by beating or sweeping the sandy beaches and rank vegetation growing in such localities.

These insects have usually been included with the crickets, but the present writer prefers to set them aside as a distinct suborder with affinities to both the locusts and the crickets. There are much fewer forms in this suborder than are found in other groups of orthopterous insects. This is probably due to their somewhat restricted distribution, due to their burrowing and moisture-loving, or subaquatic, habits.

Family GRYLLOTALPIDÆ.

Genus GRYLLOTALPA Latreille.

Gryllotalpa LATREILLE, Hist. Nat. Crust. Ins., III, p. 275 (1802). For rather full synonymy see Kirby, Syn. Cat. Orth., II, p. 4 (1906).

89. **Gryllotalpa africana** (Beauvois).

Gryllotalpa africana BEAUVOIS, Ins. Afr. Amer., p. 229, pl. 2c, fig. 6 (1805), and numerous other authors (see Kirby, *l. c.*, p. 6).

There are two specimens of this species at hand, which were taken at Lolodorf, by A. I. Good, and one from Batanga, collected by F. H. Hope.

Family TRIDACTYLIDÆ.

Genus TRIDACTYLUS Olivier.

Tridactylus OLIVIER, Enc. Meth., Ins., IV, p. 26 (1789); for further synonymy see Kirby, *l. c.*, p. 7.

90. **Tridactylus digitatus** (Coquebert).

Acheta digitata COQUEBERT, Ill. Icon. Ins., III, p. 91, pl. 21, fig. 3 (1804).
Tridactylus digitatus SAUSSURE, Mém. Soc. Génève, XXV, p. 52 (1877). Additional synonymy is given by Kirby, *l. c.*, p. 8.

The single specimen of this species at hand was taken by A. I. Good at Lolodorf, on November 11, 1913. C. M. Acc. No. 5264.

Suborder ACHETOIDEA.

The crickets, although not as numerous as either the short-horned grasshoppers or locusts, or the long-horned grasshoppers, are, nevertheless, quite abundant in both genera and species. Like both of those suborders of the saltatorial orthoptera just mentioned, the present group is most numerously represented in subtropical and tropical countries. This statement is especially true of the more humid sections of those countries where the great forests and jungles of the world are to be found. In and about these they abound in great variety as to size, habits, etc. Thus far the group has been less collected and even less studied than other orthopterous insects.

Generally speaking, the crickets are less attractive than are the representatives of either of the "grasshopper" groups, because they are as a rule either dull in color, or do not possess striking structural

features. They are also mostly nocturnal in their movements, and many of them invariably lie hidden away during daytime among dead leaves and other rubbish, which litters the floor of forests. Some burrow into the earth, while still others hide beneath stones, fallen trees, in crevices, and under loose bark, or in any other nook or cranny, which offers concealment and protection from enemies and the light of day. Many of the forms are likewise rather small, very active, and live among the dense foliage of shrubs, bushes, vines, and trees, as well as in the grasses and other herbage of prairies, meadows, and swamps. A few burrow in the mud and damp sand of beaches, and at the margins of streams, while a few are strictly aquatic. Some species even live in and about the nests of ants, where they are both tolerated and protected.

The crickets, therefore, might be considered as being the most highly developed of the saltatorial orthoptera, *i.e.*, the farthest removed from primitive types.

The present collections do not happen to contain many representatives of the group, although the region under consideration no doubt is the habitat of a considerable number of both genera and species.

Family NEMOBIIDÆ.

Genus NEMOBIUS Serville.

Nemobius SERVILLE, Ins. Orth., p. 345 (1839) and numerous authors since. For references see Kirby, Syn. Cat. Orth., II, pp. 13, 14.

91. **Nemobius** sp.?

There is but a single specimen of the Nemobiid group at hand. This insect is referred to the genus *Nemobius* without trying to determine the identity of the species. It also belongs with the collections made by F. H. Hope at Batanga, and was taken in February, 1914. In size this specimen is among the very smallest of the species of the genus, likewise very slender, with caudate wings.

Family BRACHYTRYPIDÆ.

Genus BRACHYTRYPES (Serville).

Brachytrupes SERVILLE, Ins. Orth., p. 323 (1839); BOLIVAR, Ortopt. Espań., p. 276 (1876); IB., An. Soc. Espań. Hist. Nat., VIII, p. 72 (1898).

Brachytrypes AGASSIZ, Nom. Zoöl. Ind. Univ., p. 52 (1846); FISCHER, Orth. Eur.,

p. 186 (1853); BRUNNER, Prodr. Eur. Orth., p. 438 (1882); FIEBER, Syn. Eur. Orth., p. 64 (1854); IB., Lotus, V, p. 66 (1855).
Brachytrypus SAUSSURE. Mém. Soc. Génève, XXV, p. 115 (1877).

92. **Brachytrypes caviceps** Karsch.

Brachytrypes caviceps KARSCH, Berlin. Ent. Zeitschr., XXVIII, p. 148 (1893).

Two females and two nymphs of this genus are determined as belonging to *B. caviceps* Karsch. They come from Batanga, where they were taken by F. H. Hope, in March and April, 1914.

These females agree with the description of the male in their coloration and have the tegmina just reaching to the tip of the abdomen. The ovipositor is moderately stout, with acuminate tip, and only about two millimeters long.

Genus GYMNOGRYLLUS Saussure.

Gymnogryllus SAUSSURE, Mém. Soc. Génève, XXV, p. 123 (1877); KIRBY, Syn. Cat. Orth., II, p. 23 (1906).

93. **Gymnogryllus miurus** Saussure.

Brachytrypus miurus SAUSSURE, *l. c.*, p. 131 (1877).
Brachytrypus miurus KIRBY, *l. c.*, p. 23 (1906).

There are three males, three females, and one nymph before me. They were collected by F. H. Hope at Batanga. C. M. Acc. No. 5293.

Family ACHETIDÆ.

Genus GRYLLUS Linnæus.

Gryllus LINNÆUS, Syst. Nat. (Ed. X), p. 425 (1758), and practically every entomologist since. For the main references see Kirby, Syn. Cat. Orth., II, p. 27.

94. **Gryllus conspersus** Schaum?

Gryllus conspersus SCHAUM, Bericht. Akad. Berl., 1853, p. 776; IB., Peters' Reise n. Mossamb., V, p. 117 (1862); SAUSSURE, Mém. Soc. Génève, XXV, p. 183 (1877).

The *G. conspersus* of Schaum appears to be represented by a single male and two females, which were taken by F. H. Hope in March and April, 1914, at Batanga.

95–99. **Gryllus** spp.?

There are also representatives of what appear to be at least half a dozen other species of the genus *Gryllus*. They were collected by the same party at Batanga.

The genus is difficult to work, and requires good and ample material to produce accurate results. I am accordingly postponing final determination for a later date.

Family PLATYBLEMMIDÆ.

Genus ALLUAUDIELLA Bolivar.

Alluaudiella BOLIVAR, Bull. Soc. Ent. France, LXII, p. cccx (1893); KIRBY, Syn. Cat. Orth., II, p. 47 (1906).
Alluaudia BOLIVAR (*nec* Lameere), Ann. Soc. Ent. France, LXII, p. 181 (1893).

100. **Alluaudiella ? flavopicta** Bolivar?

Alluaudia flavopicta BOLIVAR, *l. c.*, p. 183 (1893).
Alluaudiella flavopicta KIRBY, *l. c.*, p. 47 (1906).

I find two males of a species of cricket before me, which belong in the Platyblemmid series, and possibly, but not certainly, to the genus *Alluaudiella* and the species *flavopicta* of Bolivar, but the descriptions of both the genus and species do not fit the material at hand. In the first place, these insects do not have the "body greatly flattened" nor especially smooth or polished, the head is not noticeably transverse, nor is the face or front almost horizontally sloped to the rear. In the second place the coloration is somewhat different from that attributed to *flavopicta*.

The main characteristic, however, of these specimens, which inclines me to consider them different, is the large flattened basal antennal joint or segment, the outer apex of which is produced into a long, somewhat flattened, gently curved outwardly directed tooth, or horn, which is a little longer than the rest of the joint. These specimens come from Batanga, where they were collected in February and April, 1914, by F. H. Hope. C. M. Acc. No. 5293.

In a synoptical key prepared by Saussure (Rev. Suisse de Zoöl., V, p. 794, 1898), these specimens run to the genus *Scapsipedus*, as they also do in a key prepared by Karsch, and contained in a paper on saltatorial orthoptera coming from Togoland and Adeli, West Africa (Berlin. Ent. Zeitschr., XXXVIII, p. 154, 1893). The described African species of this last-named genus are quite distinct from our specimens.

Family ŒCANTHIDÆ.

Genus HOMŒAGRYLLUS Guérin.

Homœogryllus GUÉRIN, LeFebvre, Voy. Abyssinie, VI, p. 335 (1847); SAUSSURE, Mém. Soc. Génève, XXV, p. 421 (1878).

101. **Homœogryllus reticulatus** (Fabricius).

Acheta reticulata FABRICIUS, Spec. Ins., I, p. 354 (1781).

Homœogryllus reticulatus SAUSSURE, *l. c.*, p. 425, pl. 16 (XXXIX), fig. 2, pl. 19 (LXXVII), fig. 2 (1878). For additional synonymy see Kirby, Syn. Cat. Orth., II, p. 66 (1906).

F. H. Hope took two males of a representative of this genus at Batanga, which I do not hesitate to refer to *H. reticulatus* (Fabricius). A single female, however, coming from the same locality is placed here with some doubt, since it has somewhat larger dimensions than those given for this sex of *H. reticulatus*. All three of these specimens were collected in March and April.

Family TRIGONIDIIDÆ.

Genus CYRTOXIPHA Brunner.

Cyrtoxipha BRUNNER, Mitth. Schweiz. Ent. Ges., IV, p. 168 (1873); SAUSSURE, Miss. Sci. au Mex., Orth., p. 373 (1874); KIRBY, Syn. Cat. Orth., II, p. 80 (1906).

Cyrtoxiphus SAUSSURE, Mém. Soc. Génève, XXV, p. 476 (1878); BRUNNER, Ann. Mus. Genova, XXXIII, p. 210 (1893).

102. **Cyrtoxipha ciliata** (Afzelius & Brannius).

Acheta ciliata AFZELIUS & BRANNIUS, Achet. Guin., p. 27, fig. 8 (1804).

Cyrtoxiphus ciliatus SAUSSURE, *l. c.*, p. 490 (1878).

Cyrtoxipha ciliata KIRBY, *l. c.*, p. 80.

A. I. Good took a single female of what appears to be this species at Lolodorf, on October 29, 1913, C. M. Acc. No. 5264. This specimen is mutilated, and besides much covered by mould, so that it is somewhat difficult to examine critically.

103. **Cyrtoxipha furva** Karsch.

Cyrtoxiphus furvus KARSCH, Berlin. Ent. Zeitschr., XXXVIII, p. 162 (1893).

Cyrtoxipha furva KIRBY, *l. c.*, p. 81 (1906).

There is also a single specimen at hand of Karsch's *C. furvus*. It comes from Batanga, where it was collected in March, 1914, by F. H. Hope. C. M. Acc. No. 5293.

Family ENEOPTERIDÆ.

Genus EUSCIRTUS Guérin.

Euscirtus GUÉRIN, Icon. Reg. Anim., Ins., p. 334 (1844); KIRBY, Syn. Cat. Orth., II, p. 101 (1906).

Euscirtus SAUSSURE, Miss. Sci. au Mex., Orth., p. 500 (1874); IB., Mém. Soc. Génève, XXV, p. 622 (1878).

104. **Euscirtus bivittatus** Guérin.

Euscirtus bivittatus GUÉRIN, *l. c.*, p. 334 (1844).

Euscirtus bivittatus SAUSSURE, Mém. Soc. Génève, XXV, p. 624, pl. 19 (LXIX), figs. 1, 1*a*, 1*d*, 1*h*, 1*b* (1878). For additional synonymy see Kirby, *l.c.*, p. 101.

One male and two females of this insect are at hand. They come from Batanga, where they were taken by F. H. Hope. C. M. Acc. No. 5293.

105. **Euscyrtus planiceps** Karsch.

Euscirtus planiceps KARSCH, Berlin. Ent. Zeitschr., XXXVIII, p. 166 (1893).

Euscyrtus planiceps KIRBY, *l. c.*, p. 101 (1906).

This species is represented by a mutilated female taken by F. H. Hope at the same locality as the preceding.

III. DIPLOMYSTUS GOODI Eastman.

By W. J. Holland.

(Plate I.)

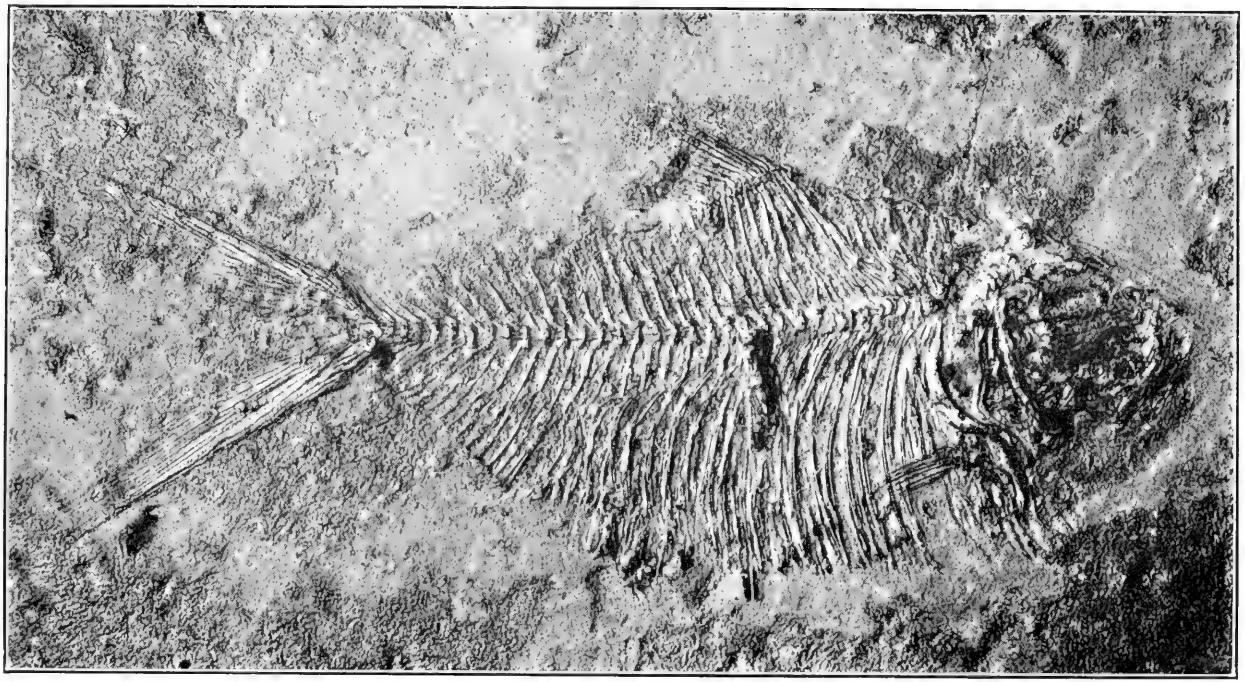
In the Annals of the Carnegie Museum, Vol. VIII, pp. 370–378, Plates XXIII and XXIV, the late Dr. Charles R. Eastman gave an account of some fossil fishes obtained by Mr. Albert I. Good at Benito, Spanish Guinea. To one of the species Dr. Eastman gave the name *Diplomystus goodi* (Cf. *l. c.*, p. 375) and upon the plates which accompany his article he gave figures carefully prepared by Mr. Sidney Prentice of the material upon which his description was based.

Since Mr. Good first collected at the spot others have resorted to it and have dug up from the bituminous shales at the edge of the sea a number of slabs upon some of which are preserved better impressions of the skeletal remains than were in our possession at the time Dr. Eastman prepared his article. A comparatively recent accession to the Section of Vertebrate Paleontology in the Carnegie Museum consists of a number of slabs (Acc. No. 6119) upon one of which are preserved the remains of *Diplomystus goodi* in much better condition than was the case with the type specimen upon which Dr. Eastman wrote. It has seemed to the writer that it might be well to reproduce and publish a photograph of this particular slab, as it will serve to convey to the student a better idea of the species than can be obtained from the figures cited above.

As Dr. Eastman observed, the shale is highly charged with carbonaceous matter, and the specimen reproduced shows about the middle of the ventral region a dark mass, which appears to the writer to be a bit of fossil vegetable matter superimposed upon the vertebræ and ribs at that point. The laminæ of the shale containing the fossil remains are often quite thin and blackish or paler brown in color, and are intercalated between layers of fine sandy shale, which are of varying thickness. In the case of the present specimen the fish is preserved in a layer only a few millimeters in thickness, which is imbedded upon a slab of gritty grey sandstone about an inch in

thickness. Other specimens in our possession are very thin slabs which resemble pieces of compressed peat both in color, texture, and weight. They are very delicate and frail, but preserve remarkably well the outlines of the remains imbedded in them. Upon one of them I am able to detect a foot-print, apparently that of a batrachian.

CARNEGIE MUSEUM,
July 20, 1920.



Diplomystus goodi Eastman $\times\frac{1}{1}$.

IV. MORPHOLOGICAL FEATURES OF CERTAIN MUSSEL-SHELLS FOUND IN LAKE ERIE, COMPARED WITH THOSE OF THE CORRESPONDING SPECIES FOUND IN THE DRAINAGE OF THE UPPER OHIO.*

By Norman McDowell Grier.

(Plates II–III.)

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I. Acknowledgments.

To Dr. W. J. Holland, Director of the Carnegie Museum, I am indebted for the use of the facilities of that institution in pursuing this research. In other ways also he made possible its completion, as did Dean J. C. Fetterman of the College of Arts of the University of Pittsburgh. Dr. Arnold E. Ortmann, Curator of Invertebrates in the Carnegie Museum, besides suggesting the problem, has with his

* Submitted to the Graduate School of the University of Pittsburgh as a major thesis in partial fulfillment of the requirements for the degree of Doctor of Philosophy, June, 1919.

usual scientific zeal most unselfishly contributed such of his own observations as seemed to have a direct bearing upon the matter in hand. Too much can not be said in appreciation of the kindness of Dr. Ortmann, while almost equal indebtedness is felt toward Dr. O. E. Jennings of the Museum.

From time to time I called upon other eminent and enthusiastic students of the *Naiades* for the benefit of their experiences in certain phases of the problem. Those who have cheerfully responded are Dr. Bryant Walker, Dr. C. B. Davenport, Dr. A. F. Shira, Director of the Biological Station at Fairport, Iowa, and Messrs. W. I. Utterback, Calvin Goodrich, and L. S. Frierson. Finally my thanks are due to Miss D. M. Smith, a Y. M. C. A. Welfare Worker in France, who aided considerably in the revision of the text.

II. INTRODUCTORY.

The primary purpose of the investigation here recorded has been to determine as precisely as possible in morphological terms what are the distinctions which exist between the species of *Naiades* found in the upper drainage of the Ohio River and their varieties in Lake Erie; and secondarily by a comparative examination of these differences to endeavor to reach definite conclusions as to the effects produced by the two environments as causative of these differences.

As with other classes of Mollusca, if we except such work as that of C. C. Adams (1)* on the freshwater snail *Io*, the phases of local variation in American species have received rather indifferent treatment from zoölogists. While they have been made the subject of comment in a number of scattered papers by European investigators dealing with American forms, they have principally received attention in the more purely economic publications of the U. S. Bureau of Fisheries, and there, as the examination of the literature shows, only incidentally from an ecological rather than from a morphological standpoint.

L. V. Hueber (20) writing upon *Unio fasciculus* records physical differences between individuals of this species found in rivers and canals. He notes that the growth-lines are more distinct in the quieter waters of canals; that, when viewed from in front, mussels from the rivers appear wedge-shaped, those from the canals more oval. Julius

* The numbers in parentheses refer to the Bibliography, Section XI of this paper.

Hazey (16) deals with *Unio pictorum*. He states that in rapidly flowing brooks the shells become long, straight, narrow, with narrow growth-lines and rounded extremities, while in the quiet waters of the main stream (Danube) is found a high, flat form, with broad lines of growth, rounded posteriorly, and with short anterior border. He further remarks that transitional forms representing this species occur in places intermediate between the swift brooks and the quieter river, and points out that typical *Unio pictorum* is developed in stagnant water, but in swifter currents becomes elongate, producing the variety *longirostris*. He shows that the "beak" obtains its greatest growth in swiftly flowing streams. An excellent paper by H. Wallengren (56) deals at some length with the matters which the two previously mentioned writers discuss.

With the appearance of the paper of H. Sell (45) there began a revival of interest in this particular field of investigation, which has continued to the present time. As the result of extensive comparisons Sell concludes that in mussels found in certain lakes and rivers the anterior portion of the shell is thicker in the latter and weaker in the lakes. He associates a long rather than a curved lower border with strong currents, regarding it as giving greater protection. Lake forms are comparatively inflated and have protruding growth-rings. He accounts for the presence or absence of the growth-rings by the degree of the disturbance of the water. Forms from still water are somewhat more symmetrical in outline, and he states as a general principle that the size of *Unios* seems to be proportionate to the size of the body of water in which they are found.

O. Buchner (5) observes that *Anodonta* sp. reaches its greatest development on muddy bottoms, becoming compressed in brooks. This alteration in the shape of the shells, resulting in the production of varieties, he is inclined to attribute to nutritive conditions. He also recognizes transitional forms originating in the different environments. W. V. Israel (22, 23, 24) besides corroborating the statements made by the writers already quoted, dwells at length upon *Unio crassus*, noting that it is shorter in brooks than in quiet waters (*cf.* V. Hueber) in which it becomes larger, with a curved inferior border. In strong streams and cataracts, especially where gravel is found, he observes that the mussels become stronger in structure, shortened, and rounded. He distinguishes three varieties of *Unio pictorum* formed in the way indicated: (*a*) the common typical form of the larger rivers; (*b*) a

form as broad or broader than long from sandy bottoms; (*c*) a thick-shelled form from rapid waters. He adds that forms from still water and muddy streams have a prolonged posterior end, which is not so well developed in rapid currents.

M. C. March (30) apparently began a statistical study along the same lines pursued in this paper, plotting variation curves based upon the relation between the antero-posterior or horizontal axis and the dorso-ventral or perpendicular axis. Only a short note was published, of which the following summary is given. March states that in *Unio tumidus* and *Unio pictorum* two main types of shell occur: one stout and heavy with relatively long dorso-ventral axis; the other with short antero-posterior axis, etc. March believes that the growth of the anterior portion of the shell is slower than that of the posterior portion, "as is natural with an animal, which has to plough its way through the mud." An increase in the rate of the current in which they live would produce a decrease in pre-umbonal development, and thus tend to give the umbo a more forward position in those forms which inhabit strong currents. Such forms are found in canals having strong gradients, those otherwise modified in deeper canals with an abundance of locks. Thick mud is supposed to induce elongation, slow rivers develop forms with long dorso-ventral axes.

A paper by Clessin (6) published later contains many interesting side-lights upon the history of the *Naiades*, but nothing of immediate interest to us. Finally Haas & Schwarz (15) propose as a law the statement, which this paper endeavors as the result of investigation to prove, that "The *same* types under the same biological (ecological) conditions produce the same variants; *different* types under like conditions produce convergent (parallel) local variants. In the case of a sufficiently lengthy isolation the local variants subject to biologically similar environments, may become constant or fixed local forms." (*Free translation.*)

The above completes a resumé of all the European literature to which I have had access. While a large part of it, as well as the literature hereafter cited, may not appear to have much bearing upon the results of the following investigation, I believe that a reference to it is essential to a complete understanding of the nature of the problem. The following references to investigations made upon our American forms are added as bearing upon the same or closely related species, with which I deal later.

Wilson & Clark (59) state that *Anodonta grandis* is lacustrine by choice, and that in lakes the shell is typically inflated and thinner, while in creeks it becomes it becomes thicker, more compressed, elongated. Later (61) they note that where two closely related forms of *Naiades* differ essentially in the degree of inflation of the shell, the flatter and less inflated form is found in the upper portions of the river and in its tributaries, while the rounder and more inflated form is confined to the lower stretches of the main stream where there is a weaker current and more mud. They found, however, a notable exception in the case of *Symphynota* (*Lasmigona*) *costata*. They also note that the swiftness of the current, the size of the stream, and the kind of bottom affect other characters of the shell besides its degree of inflation. Further (60) they say: "Below the Cumberland Falls in limestone formations the water contains a considerable percentage of lime. Here the shells are much larger and thicker than above the Falls." Danglade (11) writing with regard to the Illinois River, states that the mussels become smaller in the lower stretches of the stream. He states with regard to *Quadrula metanevra* that one of the examples before him has 'the markedly pinched posterior dorsal portion' generally found in the lower Wabash. He says of *Quadrula undulata* that it 'becomes inflated lower down the river.' With regard to *Obliquaria reflexa* he says: "In the Peoria lake-region, where the current is slow and the bottom is composed of soft mud, the shell is often very heavy and rounded anteriorly, while posteriorly it is thin and much elongated, which is no doubt the result of accomodations to natural conditions. In lower stretches the shell, although heavy and inflated, is considerably smaller than those in the upper portions of the river." Of *Plagiola elegans* he remarks: "Some examples from portions of the river having soft and mud bottoms are greatly elongated posteriorly." Utterback (51, 52) notes that in the Osage River 'flat or compressed forms are found at the head-waters where the water is shallower or swifter, and that they become heavier and more swollen further down stream, where the water is deeper and more sluggish.' He also found that the quiet, sluggish streams of northern Missouri tend to produce a heavy, rarely plicated, highly inflated shell (*Amblema*); on the other hand the swift clear water of the streams of southern Missouri give origin to compressed multiplicated shells.

Objection to the statement that *Naiades* become more inflated in the lower reaches of streams is offered by that eminent student of the

Mollusca, Dr. Bryant Walker (1914–1916) and his view is interesting for the reason that it brings out points which will be later discussed in this paper. In a letter to the writer Dr. Walker mentions two contradictory cases, saying: "Practically all the *Naiades* of the Great Lakes are much smaller than the examples of the same species from the inland streams tributary to the lakes. This may be the result of the great difference in temperature or less abundant food-supply (this also possibly the result of temperature) or the combined result of both." But, as indicated, this may be due to an absolutely different environment, with other unexplainable factors. Again Dr. Walker says: "In the case of *Quadrula elliotti*, which comes from a small creek in N.W. Georgia, where it grows very large, the species seems to run into *Quadrula atrocostata* of the Coosa, which never grows as large as typical *elliotti*."

Ortmann (33, 34, 36, 38, 39) noted that the diameter of certain shells increases in a down-stream direction. Two distinct forms representing what was formerly considered a single species may appear. Thus we have *Obovaria subrotunda circulus* and *Obovaria subrotunda lens; Pleurobema obliquum* and *Pleurobema coccineum; Fusconaia barnesiana* and vars. *bigbyensis* and *tumescens*.

Aside from the fragmentary indirect evidence and excepting the work begun by Miss March and the more general observations of Walker presently to be discussed, there appears to have been no systematic study of these peculiar problems, which arise in connection with the development of the *Naiades*. The rich collection of the Carnegie Museum has afforded excellent opportunity for investigating the matters spoken of and at the suggestion of Dr. Arnold E. Ortmann the writer has undertaken to throw what light he can upon the subject with the help of the abundant material which has been placed at his disposition for study. This material includes the very extensive collections made by Dr. Ortmann in the rivers of western Pennsylvania and in Lake Erie during the years 1903 to 1907 inclusive, together with exchanges representing the fauna of outlying territories. The species employed by me are those which are most abundantly represented in the Museum. I have followed the arrangement and the nomenclature suggested by Sterki (50) and elaborated by Ortmann (33, 35, 36). Priority is accorded in this scheme to many of the names applied by Rafinesque (40) which have been revived by Frierson (13) and Vanatta (53) and accepted by Ortmann. The list of species used by me is here given.

III. LIST OF SPECIES EMPLOYED IN THIS INVESTIGATION (43).

LAKE ERIE.

Fusconaja flava parvula (Grier).
Amblema plicata (Say).
Pleurobema obliquum pauperculum (Simpson).
Elliptio dilatatus sterkii (Grier).
Symphynota costata eriganensis (Grier).
Anodonta grandis footiana (Lea).
Paraptera fragilis (Rafinesque).
Proptera alata (Say).
Anodontoides feruss. subcylindricus (Lea).
Eurynia recta (Lamarck).
Lampsilis luteola rosacea (Dekay).
Lampsilis ovata canadensis (Lea).

UPPER OHIO.

Fusconaja flava (Rafinesque).
Amblema costata (Rafinesque).
Pleurobema obliquum coccineum (Conrad).
Elliptio dilatatus (Rafinesque).
Symphynota costata (Rafinesque).
Anodonta grandis (Say).
Paraptera fragilis (Rafinesque).
Proptera alata (Say).
Anodontoides ferussacianus (Lea).
Eurynia recta latissima (Rafinesque).
Lampsilis luteola (Lamarck).
Lampsilis ovata ventricosa (Lamarck).

IV. PHYSICAL CONDITIONS AND TYPES OF NAIAD FAUNÆ.

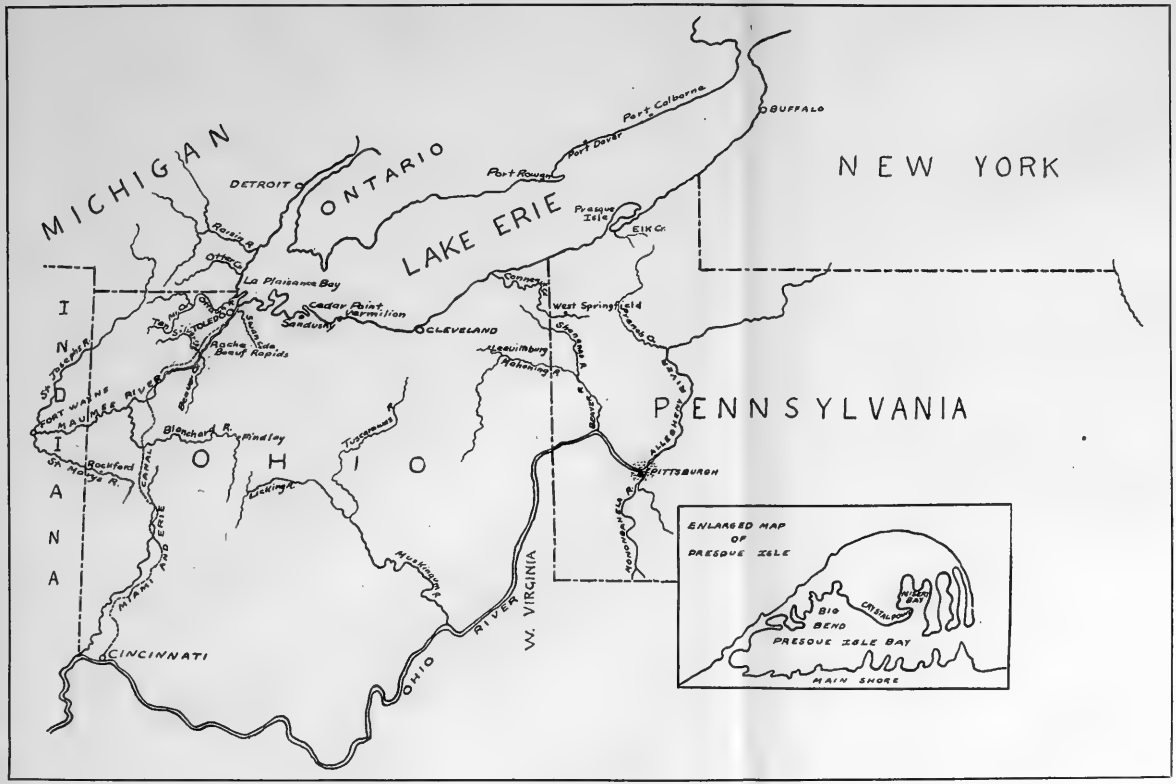
The physical conditions under which the species enumerated in the foregoing list occur may now be discussed. Lake Erie (*Cf.* Plates I and II, maps) one of the smaller Great (Laurentian) Lakes has a water surface of 9,960 square miles (42). In the part we are most largely concerned with the immediate shore consists of the soft blue Devonian shale named by Newberry (32) the "Erie shale" covered with a varying thickness of drift clay. A large amount of beach debris is annually taken into the water of Lake Erie from this region and almost the entire shore from Sandusky Bay eastward represents a typical beach of sand or gravel, strewn here and there with boulders from the drift-clay above. Especially after storms the streams flowing into the lake are frequently turbid and heavy with sediment, but the St. Lawrence River flowing from the Great Lakes is usually clear and free from all but the finest material in suspension (25). The coarse sediment brought into the lake is swept along the coast by the shore-currents and mingled with the pebbles and sand derived from the wear of the land by shore-waves, or deposited in stratified layers on the lake-bottom. The finer products of the wash of the land or of shore-erosion are thus carried lakeward. In general, the sheet of material thus spread out is thickest and coarsest near the shore, and becomes finer and thinner as the distance from shore increases. The coarse strata in the shore-deposits overlap and dovetail lakeward with the outer layers of fine sediment in the central part of the basin. So

far as the bottom is concerned, conditions in Presque Isle Bay (44), the principal source of material used in this investigation, represent the extreme of finest sediment.

The friction of wind on the surface of the lake produces very decided movements in the waters. On the Laurentian Lakes, waves fifteen to eighteen feet in amplitude have been observed during long, continued storms. As Lake Erie is the shallowest of the Great Lakes and as its axis lies almost directly in the normal path of the cyclonic storms (25), the wave action thus produced is particularly strong at times. The effect of the prevailing westerly winds on the surface movement of the water in the lake is indicated by the trend of the principal currents. It has been found that the currents of the Laurentian Lakes have in general a speed of from four to twelve miles a day, but in certain observed instances this is increased to two and one-half to four miles per hour. When the currents follow the shore, important results in a physiographic sense may follow. When the wind blows obliquely to the shore strong currents are frequently produced which follow the general trend of the coast, but sweep across bays and inlets. These currents with the assistance of the waves sweep along sand and gravel and produce important changes in the bottom particularly where the water is shallow. The prevailing littoral current unaided is however, not strong enough to transport any considerable amount of coarser material and in a general way it may be said that the condition of the water is not as disturbed as in the Upper Ohio Drainage where a considerable amount of such material is carried along.

As a rule, the temperature of the water in Lake Erie is much cooler than that in the Upper Ohio Drainage. The shallow lakes of the Northern states have been found to have a nearly uniform temperature during the summer months of 75° F. (42). In the winter the temperature is generally 32° F. This condition has an important bearing upon the growth of *Naiades*. It is a well-known physiological fact that the rapidity of nutritive processes in "cold-blooded" animals depends largely upon the temperature to which they are subjected. Again the food of the *Naiades* consists largely of plankton.

I quote from a letter from Mr. A. F. Shira, Director of the Biological Station at Fairport, Iowa, "It may be said that an increase in the temperature of a lake favors an increase in plankton, and there is an increase in plankton during the spring and in early summer followed generally by a decrease in autumn. Temperature affects the character



Map Illustrating Sources of Material Discussed by N. M. Grier.

Map Giving Localities Mentioned by N. M. Grier.

as well as the quantity of plankton. A low temperature favors the increase and development of diatoms, while a high temperature favors especially the development of water bloom algæ, also such forms as *Vorticella*." Allen (2) claims that other algæ than diatoms form fully as large a part of the food, and lists more species of these from the digestive tract of *Naiades* than diatoms (63). The colder waters of Lake Erie would therefore tend to inhibit the growth of those forms of algæ except diatoms, even in the summer months.

With the following extract from Kofoid (27) the question of plankton as a source of food for *Naiades* may be dismissed. "Stream plankton differs from all others in the mingling of plankton from all sources, and in being subject to variation in quantity. It appears to be more subject to catastrophic change than that of the lake, possibly on account of the conditions just described. Changes in the volume of the water, the contact of shore and bottom, access of heat and light, and changes in chemical composition are frequently more extensive and more widely effective in streams than in other types of aquatic environments." Kofoid believed *Chlorophyceæ* were somewhat more characteristic of the plankton of rivers than of lakes. Silt (there is more of this in the river) is supposed to hasten the growth of plankton by providing its source of nourishment in an easily obtained form. It would follow in the writer's opinion that fluviatile *Naiades*, all factors considered, have a more abundant, if less regular, supply of food than those of the lakes. Perhaps the larger amount of silt received in the spring in the lakes accounts for abundance of plankton then, especially when coupled with the rising temperature.

Characteristics of the Mussel Fauna of Lake Erie.

The studies of Walker (54, 55) have shown that the Lake Erie fauna did not persist through the Glacial Period. Representative *Naiades* now found in the Great Lake Region of the Mississippi and Ohio Faunas are the result of post glacial invasion (47). It is Dr. Walker's opinion that to this is to be ascribed the present existence of so large a number of representatives of the Mississippi Fauna in Lake Erie. This migration may be traced at one end of the lake through the Maumee Outlet into the post glacial Lake Maumee; at the other end the ancient headwaters of the Ohio tributaries once emptied (28). Walker ascribes the modifications which have taken place in their size, shape, and appearance to the environmental

changes which have occurred since glacial time, more particularly in temperature. In addition he points out that the *Naiades* of the warm waters in the interior of the state of Michigan attain the same size, luxuriance of growth, and color as they do at the present time in the Mississippi and Ohio Valleys, although their ancestors originally came from the lake. There is, on the other hand, some evidence for believing that they may have come from northern Indiana through an ancient pre-glacial drainage (47), and another way of attacking the problem with which we are dealing, were material sufficiently abundant, would be to compare the shells of the interior waters of Michigan with those of Lake Erie. Lake Erie shells are characterized by brighter colors, when compared with their silt- and iron-stained fellows of the rivers, are exceptionally polished, and characterized otherwise in distinction by their well developed lines of growth. Dr. Walker in a letter to the writer (1914) suggested that a possible source of the depauperate quality of the shells may be the chemical quality of the water itself, pointing out that the influence of brackish water upon fluviatile species is well known, and there is no good reason why the infusion of the other materials than those in the rivers should not have their influence for good or bad in the same way. An analysis of Lake Erie water furnished through the courtesy of Mr. J. S. Dunwoody, Superintendent of the Filtration Plant at Erie, Pa., is given below, for comparison with that of the Upper Ohio Drainage at Pittsburgh, Pa. (29).

Analysis of water of Lake Erie at Erie, Pa.	Parts per million.	Analysis of water at Pittsburgh, Pa. Parts per million.
Turbidity	3–100	55
Color	30–40	122
Iron	very little	2
Alkalinity	105	47.4
Calcium carbonate	90	56
Magnesium carbonate	18	*
Magnesium sulfate	25.5	*
Calcium sulfate	a little	20
Sodium and potass. chlorides	21.8	26
Sodium and potass. sulfates	30	20

These analyses are corroborative of certain statements I have made, and furnish food for reflection.

* These substances are not recorded as being present in the water at Pittsburgh.

Physical Conditions of the Drainage Basin of the Upper Ohio.

The drainage basin of the Upper Ohio River (19, 28, 44) lies in the central part of the eastern part of the United States. The river is formed by the junction of the Allegheny and Monongahela Rivers at Pittsburgh, Pennsylvania. From that point the Ohio flows in a generally southwestern direction and joins the Mississippi at Cairo, Illinois. The principal tributaries with which this investigation is concerned (beginning at the source and following down the right or north bank) are the Allegheny and Beaver Rivers; on the left are the Monongahela River, Raccoon Creek and Chartiers Creek. The total length of the Ohio River is 767 miles and the total area drained is about 210,000 square miles. The portion of the drainage basin with which we are concerned lies in the states of New York, Pennsylvania, Ohio, West Virginia, and Maryland. The source of the tributaries from the north lies in the glaciated area, the sources of the southern tributaries are located in the steep and rocky slopes of the western side of the Appalachian Mountains. The topography varies from flat and rolling in the western and northern portions, to rough and mountainous in the southern and eastern sections.

The Allegheny River, which unites with the Monongahela River at Pittsburgh to form the Ohio, drains the western slopes of the Allegheny Mountains. The Allegheny is the larger stream, as its drainage area is nearly fifty per cent. greater than that of the Monongahela. The drainage of the Allegheny lies in the states of Pennsylvania and New York. The river rises in the central part of Potter County in the northern part of Pennsylvania; flows in a generally northwestern direction across the state line into New York, thence southward back into Pennsylvania. At Franklin in Venango County the river turns and flows southeastward to the mouth of Mahoning Creek in Armstrong County, thence it turns to the southwest and joins the Ohio at Pittsburgh. The upper Allegheny and its tributaries are plateau streams, originating upon the Allegheny plateau at an elevation of 300 feet above the main stream. The tributaries above the Clarion descend by rapids and cascades from only a height of 150 to 200 feet above the river.

The tributaries with which we are concerned beginning at the source and following down the right bank as follows: Conewango, Brokenstraw, and French Creeks; on the left bank are Potato Creek, Clarion River, Red Bank, Mahoning, and Crooked Creeks, and the Kis-

kiminetas River. The total length of the river is about 290 miles, and the total drainage area 11,000 square miles. The surrounding country is extremely rough and broken, being made up of high hills or mountains separated by deep valleys. As the limits of the basin to the west of the main river are approached, the mountainous character is lost, although the surface is still rolling and hilly. The bed of the stream is composed chiefly of glacial gravel, varying from small pebbles to cobblestones. The Allegheny River descends from an elevation of 2500 feet above tide at Olean, New York to 707 feet above sea-level at Pittsburgh, Pennsylvania. In the last eighty-two miles of its course its descent averages two feet per mile. In the region of the headwaters of the Allegheny, as well as in all streams we are dealing with, erosion is going on rapidly (4, 37) which is indicated by frequent falls and rapids (riffles), and no, or only short, stretches of quiet pools. A load of debris is carried, which moves quickly over the bottom. Further down at the maturity of the rivers, rapids become scarce, quiet pools are more numerous, and although the water moves somewhat rapidly in these it is with a steady uniform current. Mussels developed under the conditions described for the region of the headwaters are those we are comparing with those from Lake Erie, and are characteristic of the various small tributaries seen on the map. We are concerned with the tributaries of the Monongahela and Ohio River rather than with those streams themselves.

The conditions surrounding the affluents of the Monongahela and those entering the Ohio from the south are much the same as those of the upper Allegheny and its tributaries and we need only mention Raccoon and Chartiers Creeks flowing into the Ohio, and Cheat River, Dunkard, and Ten-Mile Creeks, tributaries of the Monongahela, as sources from which our material has been derived.

Drainage Basin of the Beaver River.

The Beaver River is formed by the junction of the Shenango and Mahoning Rivers in western Pennsylvania and flows southeasterly twenty-two and one-half miles to the Ohio River. Above New Castle its basin lies in the glaciated area, containing broad valleys with many swamps and ponds. The main valley as far as Wampum is broad with wide flat bottom-lands. The principal tributaries are the Con-

noquenessing and Slippery-rock Creek. The Shenango River, a tributary, arises in northwestern Pennsylvania, and flows eighty-seven and one-half miles through the glaciated area, where are many swamps and small lakes, and the country is generally broad and flat, to its junction with the Beaver. The principal tributaries are Pymatuning Creek, Little Shenango River, and Neshannock Creek. The Mahoning River arises in Ohio, flowing twelve miles in Pennsylvania to its junction with the Shenango to form the Beaver. Its course is through broad valleys and rolling hills in the glaciated region. The majority of these streams are of comparatively recent (glacial) origin.

Characteristics of the Naiad Fauna.

The fauna of the Ohio River (37) and tributaries is that of the interior basin and is largely post-glacial in origin, having migrated up stream in post-glacial times. The most conclusive evidence points to its original source as having been in the drainage of the Tennessee River. The fauna may be traced from the Licking River up through the whole Upper Ohio Drainage into the headwaters of the Allegheny and the Monongahela. As a whole it may be considered a somewhat depauperate Tennessee fauna (37) becoming (although richer and more exuberant than that of Lake Erie), more greatly so in the rivers above Pittsburgh, in the Allegheny and its tributaries to a greater extent than in the Monongahela and its tributaries. In the latter and its tributaries the rich Ohio fauna, only slightly depauperated, goes up to a certain point at the lower end of canyons where begin extremely rough portions of the rivers. The species of shells found in the Monongahela, but not the Allegheny, are pre-eminently "big river forms" while those of the Allegheny are those of a small river. The Beaver River is a glacial drift stream. Wetherby remarks (58) "It is a significant fact that those North American rivers which contain the richest Unione Fauna drain Mesozoic and Tertiary regions, while those that drain Paleozoic and Azoic regions have a comparatively meagre Unione Fauna."

Summary of the Physical Conditions in Lake Erie and the Upper Ohio Drainage which affect the Naiades.

Lake Erie resembles "big streams" in having the sandy and gravelly bottom, preferred by Mollusca. The shells are not subject to the

agitation of the water occurring in the streams, as is shown by the well preserved condition in which they are collected. While the water is colder, it is clearer; there is a more even temperature. Streams in summer may nearly dry up, or in winter become solidly frozen. Such conditions do not occur in Lake Erie. The effect of this environment is shown in the *regular growth lines* of the shells and their brighter colors. On the other hand the waters of the Upper Ohio Drainage are usually warmer, contain less lime, and the food conditions are less stable, if even at times food is more abundant.

V. The accompanying table giving the list of localities at which collections were made, will give some idea of the distribution of the species employed in this research.

VI. METHOD OF MEASUREMENT.

A careful selection was first made of the material on hand to eliminate all stunted or otherwise abnormal specimens. The following data were then recorded from usually the right valve of each animal:

1. Length = L. With vernier caliper. (Scientific Materials Company Catalog No. 3930.)
2. Dorso-ventral diameter = D.V.D. With vernier caliper.
3. Dextro-sinistral = D.S.D. With vernier caliper.

4 and 5. Distances anterior; (*AD*), and posterior, (*PD*, from *DVD* to extremities of valve, (the sum giving total antero-posterior dimension), length, *D*, of shells, with a modification of the stadiometer used by Davenport in his studies on "Evolution of Pecten" (13).*

* The stadiometer as made by the writer consisted of a nearly circular box-like base of sheet-iron about fourteen inches in diameter and one-half inch in width, one end of which was squared. To this end in the cavity of the box was soldered in an inverted position the upper jaw of a vernier caliper like that already mentioned, so that the zero-point coincided with the upper surface of the box. The upper jaw of the caliper was free to move up and down the graduated scale. On the upper surface of the box there was then pasted metrically ruled paper, and a zero-point established to coincide with the zero-point of the caliper, after which the centimeter spaces were numbered to the right, to the left, and to the opposite end of the instrument. In using the instrument it was the custom to take the most convenient valve of the mussel, place it upon the base of the instrument with the umbo, or its probable location, as far as could be determined, on the zero-point. Dimensions *AD* and *PD* could be readily taken, and if desired, *DVD*, and by manipulation of the free arm of the caliper until flush with the surface of the valve, one-half of the dextro-sinistral diameter from the graduated arm of the caliper.

TABLE I.

List of Localities.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Fusconaia flava.	*Amblema costata.*	*Pleurobema obliquum coccineum.*	*Elliptio dilatatus.*	*Lasmigona costata.*	*Anodonta grandis.*	*Anodontoides ferussacianus.*	*Carunculina fragilis.*	*Proptera alata.*	*Eurynia recta latissima.*	*Lampsilis luteola.*	*Lampsilis ovata ventricosa.*
DRAINAGE OF UPPER OHIO RIVER.												
1. Potato Creek, Smethport				*	*							
2. Allegheny River, Larabee			*	*	*					*	*	*
3. " " Warren			*	*							*	*
4. Conewango Creek, Russell			*	*						*		*
5. Allegheny River, Hickory			*	*							*	*
6. Brokenstraw Creek, Garland					*	*						
7. Allegheny River, Tionesta			*	*	*						*	*
8. " " Walnut Bend		*	*	*	*						*	*
9. Sandy Creek			*	*	*	*						
10. Allegheny River, Parker's Landing				*								*
11. " " Templeton			*	*					*	*	*	*
12. " " Mosgrove		*		*						*	*	*
13. " " Rosston	*	*	*			*				*	*	*
14. " " Kelly	*	*	*	*	*			*	*	*	*	
15. " " Godfrey	*	*	*	*	*		*	*				*
16. " " Johnetta	*	*		*	*					*	*	*
17. " " Aladdin		*	*							*	*	
18. Buffalo Creek, Harbison			*	*	*							
19. Allegheny River, Schenley				*				*				
20. " " Natrona			*						*			
21. Harmarville Pond						*						
DRAINAGE OF FRENCH CREEK.												
22. Le Boeuf Creek		*	*	*	*	*					*	
23. Cambridge Springs		*	*	*	*	*				*	*	*
24. Conneauttee Lake					*	*					*	
25. Conneauttee Creek			*			*				*	*	
26. Meadville		*		*			*			*		
27. Conneaut Lake										*	*	
28. " " N.E. Shore				*			*					
29. " " E. Shore				*		*						
30. " " W. Shore			*	*								
31 " " Outlet		*	*	*	*		*			*	*	
32. French Creek, Cochranton		*		*	*					*	*	
33. " " Utica		*	*	*		*						
34. Sugar Creek, Cooperstown					*	*						
35. Little Mahoning Creek, Goodville		*		*		*				*	*	*

TABLE I.—*Continued.*

List of Localities.	*Fusconaja flava.*	*Amblema costata.*	*Pleurobema obliquum coccineum.*	*Elliptio dilatatus.*	*Lasmigona costata.*	*Anodonta grandis.*	*Anodontoides ferussacianus.*	*Paraptera fragilis.*	*Proptera lata.*	*Eurynia recta latissima.*	*Lampsilis luteola.*	*Lampsilis ovata ventricosa.*
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
DRAINAGE OF CROOKED CREEK.												
36. Creekside	*			*						*		*
37. South Bend	*			*								*
38. Rosston	*											*
DRAINAGE OF KISKIMINETAS RIVER.												
39. Yellow Creek, Homer				*								
40. Quemahoning Creek, Stanton's Mills				*	*							
41. Conemaugh River, New Florence			*									
42. Loyalhanna River, Ligonier				*								*
43. " " Idlepark			*	*	*							*
DRAINAGE OF MONONGAHELA RIVER.												
44. Cheat River, Cheat Haven		*		*								*
45. Dunkard Creek, Mt. Morris	*	*	*	*	*	*					*	
46. " " Wiley	*										*	*
47. Ten-Mile Creek, Waynesburg	*			*	*							*
48. " " Amity	*			*		*						
49. " " Clarksville											*	
50. Monongahela River, Millsboro	*			*							*	*
51. " " Charleroi	*			*	*			*				
52. " " Westmoreland Co.	*			*	*				*			
53. " " Elizabeth	*				*						*	*
54. Chartiers Creek, Carnegie	*											*
55. Ohio River, Neville Island		*		*	*			*	*	*	*	*
56. " " Coraopolis				*				*	*	*		*
57. " " Dead Man's Island												*
58. " " Edgeworth												*
59. " " Beaver											*	
DRAINAGE OF BEAVER RIVER.												
60. Padan Creek, Linesville		*				*	*					
61. Randolph Run, Hartstown											*	
62. Shenango River, Jamestown		*	*	*	*	*					*	
63. " " Greenville				*			*					*
64. " " Shenango		*	*	*								*
66. " " Sharpsville		*	*	*	*		*					
67. " " Pulaski		*	*	*								*
68. " " Harbor Bridge		*	*		*							*

TABLE I.—*Continued.*

List of Localities.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Fusconaia flava.	*Amblema costata.*	*Neurobasma obliquum coccineum.*	*Elliptio dilatatus.*	*Lasmigona costata.*	*Anodonta grandis.*	*Anodontoides ferussacianus.*	*Paraptera fragilis.*	*Proptera alata.*	*Eurynia recta latissima.*	*Lampsilis luteola.*	*Lampsilis ovata ventricosa.*
DRAINAGE OF BEAVER RIVER												
69. Pymatuning Creek, Pymatuning Twp.		*	*	*	*		*				*	*
70. Otter Creek					*							
71. Neshannock Creek, Leesburg			*	*	*						*	*
72. " " Eastbrook			*	*								*
73. Mahoning River, Leavittsburg, O.											*	
74. " " Edinboro		*				*					*	
75. " " Hillsville		*	*									
76. " " Coverts		*	*	*	*							*
77. " " Mahoningtown		*		*								*
78. Beaver River, Wampum		*		*	*	*						*
79. Wolfe Creek, Grove City	*		*		*	*					*	
80. Slippery Rock Creek, Rose Point					*						*	*
81. " " " Wurtemburg		*	*	*								*
82. Connoquenessing Creek, Elwood City		*										*
83. " " Harmony			*	*								*
84. " " Zelienople			*									
85. Brush Creek, Celia			*	*		*						
86. Little Beaver Creek, Cannelton				*							*	*
87. " " " Darlington				*	*						*	*
88. " " " New Galilee					*							*
89. Raccoon Creek, New Sheffield	*			*								
90. Ohio River, Shippingsport		*			*						*	*
91. " " Industry		*			*			*	*	*		
92. " " Cook's Ferry		*			*			*	*	*	*	*
93. " " Smith's Ferry					*			*	*			*
LAKE ERIE.												
94. La Plaisance Bay	*	*	*	*	*	*		*	*	*	*	*
95. Cedar Point	*	*		*		*		*	*	*	*	*
96. Vermilion, Ohio									*			*
97. Presque Isle Bay		*		*		*	*		*			
98. Presque Isle, Beach-pools						*	*				*	
99. " " East end, outer beach				*								
100. " " East end, south shore	*	*										*
101. " " Flats near west end	*			*	*	*		*	*	*	*	*
102. " " Big Bend	*	*		*	*	*	*	*	*	*	*	*
103. " " " " W. of Waterworks.	*	*		*			*	*	*	*	*	*
104. " " Misery Bay		*		*	*	*			*			

TABLE I.—*Continued.*

List of Localities.	*Fusconaia flava.* I	*Amblema costata.* II	*Pleurobema obliquum coccineum.* III	*Elliptio dilatatus.* IV	*Lasmigona costata.* V	*Anodonta grandis.* VI	*Anodontoides ferussacianus.* VII	*Paraptera fragilis.* VIII	*Proptera alata.* IX	*Eurynia recta latissima.* X	*Lampsilis luteola.* XI	*Lampsilis ovata ventricosa.* XII
LAKE ERIE.												
105. Presque Isle, Crystal Point		*	*	*				*				*
106. " " Horseshoe Pond	*											
107. Buffalo, New York							*					
108. Port Colborne											*	*
109. Port Dover							*				*	*
110. Port Rowan												*
DRAINAGE OF MAUMEE RIVER.												
111. St. Mary's River, Rockford									*			
112. Blanchard River, Finley							*				*	
113. Silver Creek, Williams County											*	
114. Maumee River, Rapids Station	*					*			*		*	*
115. " " Pond	*										*	
116. " " Allen County, Ohio											*	
117. Miami and Erie Canal	*						*					
118. Ten-Mile Creek, Silica, Ohio							*					
119. St. Joseph's River, Ohio	*											
STREAMS DRAINING INTO LAKE ERIE.												
120. Raisin River, Adrian Co., Mich.							*					*
121. Otter Creek, Monroe Co., Michigan							*				*	
122. Conneaut Creek, West Springfield			*				*					*
123. Elk Creek, Miles' Grove							*					

6 and 7. Length of anterior (*AHL*) and posterior (*PHL*) part of the hinge measured from the beak, giving the total hinge-length, by means of a steel-rule. (Scientific Materials Company Catalog No. 3946). Where the hinge-line curved, it was possible with practice to estimate the length.

8. Thickness of the valve just superior to the pallial line, in the region directly beneath the umbo. It was thought that such a measurement might be more easily correlated with the other dimensions taken. This was secured with a micrometer-screw caliper. (Scientific Materials Company Catalog No. 3934.)

The above measurements were resolved to factors for comparison by division with the length, with the exception of the thickness of the shell, which it seemed desirable to compare with the dextro-sinistral diameter, as giving more of a biological balance to this measurement, making it independent of any extraneous physical condition which might be involved. To facilitate the work of calculation, a Mannheim slide-rule was used, since the writer found by checking with calculations made by long hand that he was able to secure a fair degree of accuracy. Computations were usually made to the fourth place.

In recording the data thus obtained, it was found convenient to use a standard figuring book of twelve columns, double-page form, obtainable from most stationers. This provided ample space for any comments to be attached to any particular group. In comparison, the shells were first grouped into their respective drainages, after which the calculated data for the different localities were arranged in the order from headwaters to mouth of stream, and in the lake region from east to west. (See accompanying map, Pl. I.) Since the problem had to adjust itself to the amount of material on hand, it was not always possible to compare as large a number of shells as desirable from some localities. The smallest number was three, but since the results obtained consist of the average for the most part of a fairly large number of shells they are thought to reasonably justify the results obtained. The procedure was ordinarily to compare equal numbers of shells in each case. The kinds of comparison were as follows:

1. Comparison of *Naiades* of Lake Erie with their representative species in the streams entering the lake, principally the Maumee Drainage.

2. Comparison of these species of Lake Erie with their representative species in the streams of the Upper Ohio Drainage (Upper Allegheny and tributaries, Beaver and tributaries, etc.), as close as possible to the divide. Species from the latter drainages were at the same time compared with those of the Maumee.

The physiographical and geological considerations leading me to make my comparisons under these two heads are found in the sections dealing with "Physical Conditions" and "Characteristics of the Mussel Fauna." It is true that in Pennsylvania few or none of the shells have gone over into the lake, yet excellent authority states that the shells of the Upper Ohio resemble in a striking way those of the

lake tributaries in Ohio, and living under similar conditions. It seems that no serious mistake will be made if this is done, for there is no evidence to show that post-glacially the shells have become extremely modified. Moreover the shells from the Maumee are comparatively few in number.

If I am asked why on the other hand only specimens from streams nearest the divide are considered, it will be clear from the literature quoted, and substantiated by the opinion of excellent systematists that in the lower stretches of the Upper Ohio Drainage "big stream" conditions have so modified and are so modifying the *Naiades*, that it would be extremely difficult, if possible, to use the *same species* in a number of cases. In others, however, a paucity of material, where there is reason to believe the species is not excessively varying, has led to the utilization of material from larger streams.

VII. RESULTS.

The values obtained from these calculations are found on Table IV. For the convenience of the writer as well as of the reader the comparisons derived were then tabulated as shown in Table III from which all written conclusions are derived. Table II gives the maxima, minima, and mean of all dimensions for each species of shell from the two environments, affording closer insight into Table III. The actual measurements of the shell from which the material in Tables II and III is derived, while really belonging here, are placed at the end of the paper for the sake of convenience.

VIII. CONCLUSIONS.

The outstanding facts to be gathered from Tables II and III are:

1. All shells, with exception of *Anodontoides ferussacianus* obtain a greater degree of inflation in Lake Erie than in the Ohio. It follows from this and other evidence, which I have presented, that shells are longer in the Upper Ohio.

2. The height of a shell (*DVD*), appears to be indifferently influenced by either environment according to these measurements, although it could be stated that most species tend to be "higher" in the Upper Ohio and the tributaries of Lake Erie.

3. The evidence shows that the great majority of species tend to have a greater posterior development (*PD*), in Lake Erie, and greater anterior development (*AD*) in the Upper Ohio, etc.

TABLE II.

SHOWING MAXIMA, MINIMA, AND MEAN (RANGE OF VARIATION EXPRESSED IN PERCENTAGES) OF CERTAIN MUSSELS INHABITING LAKE ERIE COMPARED WITH CORRESPONDING MUSSELS OF THE UPPER OHIO DRAINAGE.

Mussel.	No. of Specimens.	Locality.	$\frac{DSD}{L}$.			$\frac{DUD}{L}$.			$\frac{PD}{L}$.			$\frac{AD}{L}$.			$\frac{PHL}{L}$.			$\frac{AHL}{L}$.			$\frac{TH}{DVD}$.		
			Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.
Fusconaja flava	52	U. Ohio	38	49	60	64	76	88	64	72	80	18	27	36	42	49	56	18	28	38	18	31	44
" " *parvula*	52	L. Erie	40	51	62	50	68	86	64	76	88	12	22	32	36	55	74	12	21	30	10	34	58
Amblema plicata	60	U. Ohio	30	41	52	56	70	84	64	74	84	14	22	30	48	58	68	12	21	30	16	48	80
" "	60	L. Erie	28	42	56	68	76	84	64	75	86	3	15	28	48	56	64	6	19	32	14	47	80
Pleurobema obliquum coccineum	12	U. Ohio	42	44	46	64	74	83	82	85	87	12	16	18	46	53	60	17	21	24	10	12	14
P. obliq. pauperculum	12	L. Erie	45	46	47	66	73	77	85	87	89	12	17	19	57	59	61	12	15	18	09	10	11
Elliptio dilatatus	43	U. Ohio	24	29	34	46	53	60	68	76	84	14	20	26	40	51	62	14	18	22	12	30	48
E. dilatatus sterkii	43	L. Erie	24	30	36	42	51	60	68	77	86	14	18	22	50	56	62	12	17	22	14	24	34
Symphynota costata	19	U. Ohio	20	29	38	52	58	64	72	75	78	22	26	30	40	46	52	16	21	26	14	32	50
S. costata eriganensis	19	L. Erie	28	33	38	52	55	58	72	76	80	22	24	26	50	53	56	14	20	26	16	27	38
Anodonta grandis	29	U. Ohio	28	36	44	48	56	64	68	74	80	22	30	38	36	43	50	16	23	30	.5	3	5.3
A. grandis var. *footiana*	29	L. Erie	24	34	44	42	54	66	62	70	78	20	29	38	40	45	50	18	24	30	.5	2.5	4.5
Anodontoides ferussacianus	21	U. Ohio	32	38	44	48	59	66	66	71	76	28	36	44	28	36	44	20	23	26	2	11	20
A. feruss. subcylindricus	21	L. Erie	28	35	42	48	50	52	66	72	78	22	32	44	32	39	46	18	24	30	6	11	16
Paraptera fragilis	20	U. Ohio	30	33	36	60	66	72	60	66	72	20	26	32	30	44	58	16	21	26	6	13	20
" "	20	L. Erie	26	31	36	62	72	82	66	73	80	18	25	32	42	49	56	14	20	26	6	14	22
Proptera alata	21	U. Ohio	28	34	40	62	75	88	58	61	76	22	28	34	48	53	58	16	22	28	20	37	54
" "	21	L. Erie	28	37	46	66	79	92	62	70	78	22	30	38	48	56	64	12	18	24	4	26	48
Eurynia recta	15	U. Ohio	24	27	30	36	40	44	76	79	82	18	21	24	44	52	60	44	52	60	18	48	78
E. recta latissima	15	L. Erie	24	28	32	30	38	46	74	79	84	16	20	24	46	57	68	46	54	62	14	30	46
Lampsilis luteola	90	U. Ohio	32	41	50	46	55	64	66	72	78	20	30	40	44	53	62	16	22	28	8	39	70
" "	90	L. Erie	28	38	48	42	54	66	66	73	80	20	27	34	40	52	64	16	23	30	2	25	48
Lampsilis ovata	66	U. Ohio	40	46	52	56	71	86	62	70	78	18	30	42	38	45	52	14	33	52	12	45	78
" "	66	L. Erie	38	50	62	64	77	90	58	70	82	18	30	42	34	45	56	16	26	36	12	52	92

TABLE III.

GIVING RESULTS OF COMPARISON OF VALUES FOR EACH DIMENSION IN THE TWO ENVIRONMENTS.*

$$\frac{DSD}{L}$$

(Dextro sinistral diameter, or convexity, divided by length giving degree of inflation.)

Greater Value in Upper Ohio Drainage.		Species with Even No. Cases.		Greater Value in L. Erie.	
A. ferussacianus	(4)			*Fusconaja*	(5)
				Amblema	(2–3)
				Pleurobema	(5)
				Elliptio	(4)
				Symphynota	(2)
				Anodonta	(4)
				Paraptera	(2)
				Proptera	(4)
				Eurynia	(2)
				L. luteola	(3)
				L. ovata	(4)

$$\frac{DVD}{L}$$

(Dorsal ventral diameter of value or its "height," divided by length.)

Greater Value in Upper Ohio Drainage.		Species with Even No. Cases.		Greater Value in L. Erie.	
Amblema	(3)	*Elliptio*	(2)	*Fusconaja*	(5)
Pleurobema	(3–5)	*Symphynota*	(1)	*Proptera*	(3–4)
Anodonta	(4)	*Paraptera*	(1)	*L. ovata*	(4)
L. luteola	(3)	*A. ferussacianus*	(2)		
		Eurynia	(1)		

$$\frac{PD}{L}$$

(Distance posterior to extremity from a line passing through median dorso-ventral plane of value.)

Greater Value in Upper Ohio Drainage.		Species with Even No. Cases.		Greater Value in L. Erie.	
Eurynia	(2)	*Proptera*	(2)	*Fusconaja*	(5)
L. ovata	(3–4)	*Paraptera*	(2)	*Amblema*	(3–4)
		A. ferussacianus	(2)	*Pleurobema*	(4–5)
				Elliptio	(4)
				Symphynota	(2)
				Anodonta	(4)
				L. luteola	(3)

* Number of cases in which this occurs is given after name of each species—2–3 etc. means 2 cases out of 3, etc. In species with even number of cases, number is given after each.

TABLE III.—*Continued.*

$$\frac{AD}{L}$$

(Distance anterior to extremity from a line passing through median dorso-ventral plane of value.)

Greater Value in Upper Ohio Drainage.		Species with Even No. Cases.		Greater Value in L. Erie.	
Fusconaja	(5)	*Proptera*	(2)	*L. ovata*	(3–4)
Amblema	(3)	*Paraptera*	(1)		
Pleurobema	(4–5)	*Eurynia*	(1)		
Elliptio	(4)				
Symphynota	(2)				
Anodonta	(4)				
A. ferussacianus	(3–4)				
L. luteola	(3)				

$$\frac{PHL}{L}$$

(Length of shell compared with posterior hinge-line.)

Greater Value in Upper Ohio Drainage.		Species with Even No. Cases.		Greater Value in L. Erie.	
Proptera	(4)	*L. ovata*	(2)	*Fusconaja*	(4–5)
Eurynia	(2)	*Paraptera*	(1)	*Pleurobema*	(3–5)
				Amblema	(3)
				Elliptio	(3–4)
				Symphynota	(2)
				Anodonta	(4)
				A. ferussacianus	(3–4)
				L. luteola	(2–3)

$$\frac{AHL}{L}$$

(Length of shell compared with anterior hinge-line.)

Greater Value in Upper Ohio Drainage.		Species with Even No. Cases.		Greater Value in L. Erie.	
Fusconaja	(4–5)	*Pleurobema*	(3)	*Proptera*	(4)
Amblema	(3)	*Paraptera*	(1)		
Elliptio	(3–4)	*Eurynia*	(1)		
Symphynota	(2)	*L. ovata*	(2)		
Anodonta	(4)				
A. ferussacianus	(4)				
L. luteola	(2–3)				

$$\frac{TH}{DVD}$$

(Thickness of shell divided by dorso-ventral diameter.)

Greater Value in Upper Ohio Drainage.		Species with Even No. Cases.		Greater Value in L. Erie.	
Amblema	(2)	*Elliptio*	(2)	*Fusconaja*	(3–5)
Pleurobema	(3–5)	*L. ovata*	(2)	*Anodonta*	(4)
Proptera	(4)			*Paraptera*	(2)
A. ferussacianus	(3–4)				
Symphynota	(2)				
Eurynia	(2)				
L. luteola	(2–3)				

TABLE IV.

ACTUAL MEASUREMENTS OF SHELLS USED IN A COMPARISON

Fusconaja flava parvula, LAKE ERIE.

	No. Spec.	$\frac{DSD}{L}$	$\frac{DVD}{L}$	$\frac{PD}{L}$	$\frac{AO}{L}$	$\frac{PHL}{L}$	$\frac{AHL}{L}$	$\frac{TH}{DVD}$
Lake Erie, La Plaisance Bay..	4	.5237	.7717	.794	.1946	.515	.1840	.123
Lake Erie, La Plaisance Bay..	7	.5364	.8021	.7699	.2197	.5235	.1922	.110
Lake Erie, Cedar Point.....	4	.5342	.7975	.7915	.2046	.489	.1592	.129
Presque Isle Bay, Various Localities.....	4	.518	.8131	.792	.212	.574	.2301	.119
Presque Isle Bay, Various Localities.....	7	.545	.8295	.7934	.301	.404	.1838	.121
Maumee River Drainage, Miami & Erie Canal, Allen Co., etc.....	4	.473	.7497	.765	.239	.553	.2786	.1118
Fusconaja flava, COMPARISON UPPER OHIO DRAINAGE WITH LAKE ERIE.								
Allegheny tributaries (36–38)..	27	.4481	.7663	.7175	.2740	.4901	.3150	.1175
Lake Erie (98, 99, 102).....	27	.544	.8492	.781	.2318	.529	.2154	.1140
Allegheny River (13–14).....	13	.4650	.7678	.7369	.2712	.4992	.2354	.0958
Lake Erie (98, 99, 102).....	13	.560	.788	.796	.1927	.522	.1958	.1007
Lake Erie (102–119).....	16	.551	.8827	.783	.2439	.542	.2396	.1121
Monongahela tributaries (44–49).....	16	.4754	.7969	.7362	.2793	.4879	.2254	.1084
Ohio tributaries (54).....	12	.4359	.7569	.7354	.2563	.5247	.2209	.1036
Presque Isle (102–119).....	12	.539	.8542	.765	.2755	.528	.2424	.1185
COMPARISON *Amblema plicata*, LAKE ERIE DRAINAGE.								
La Plaisance Bay, Lake Erie..	5	.462	.7295	.824	.1700	.602	.1738	.1497
Sandusky Bay, Cedar Point...	5	.420	.7656	.809	.1704	.603	.194	.1080
Ibid.....	6	.427	.768	.805	.1784	.596	.1931	.1077
Presque Isle Bay (all localities).	6	.444	.7569	.821	.1710	.577	.1863	.1221
Amblema costata, COMPARISON UPPER OHIO DRAINAGE WITH LAKE ERIE.								
La Plaisance Bay, Cedar Point (98–99).....	12	.444	.757	.829	.1793	.595	.1834	.1173
Presque Isle (101–120).....	12	.426	.762	.816	.1823	.564	.1767	.1393
Presque Isle (101–120).....	15	.436	.7689	.818	.1787	.565	.1784	.1373
Allegheny River (12–17).....	15	.4391	.7688	.810	.1812	.607	.1885	.1495
Presque Isle (101–120).....	15	.436	.7689	.818	.1787	.565	.1784	.1373
Allegheny tributaries (22, 23, 26, 31–33).....	15	.3908	.7777	.760	.2364	.579	.2032	.1506
Presque Isle (101–120).....	16	.435	.7719	.819	.1758	.569	.1774	.1385
Beaver tributaries (60–78)....	16	.408	.7756	.760	.2332	.587	.1894	.1504
Presque Isle (101–120).....	7	.444	.7613	.818	.1820	.566	.1830	.1348
Beaver River (79).....	7	.459	.7667	.741	.256	.552	.2119	.1647
COMPARISON *Pleurobema obliquum pauperculum*, LAKE ERIE DRAINAGE.								
La Plaisance Bay.....	3	.468	.758	.897	.103	.619	.1262	.0964
Big Bend.....	3	.477	.662	.857	.1945	.573	.1828	.1175

TABLE IV.—*Continued.*

Pleurobema obliquum coccineum, COMPARISON UPPER OHIO DRAINAGE WITH LAKE ERIE.

	No. Spec	$\frac{DSD}{L}$	$\frac{DFD}{L}$	$\frac{PD}{L}$	$\frac{AD}{L}$	$\frac{PHL}{L}$	$\frac{AHL}{L}$	$\frac{TH}{DFD}$
Presque Isle, Lake Erie, *etc.* (101–119)	12	.468	.731	.871	.1284	.591	.1850	.1146
Allegheny tributaries (4, 16, 18, 35)	12	.451	.832	.822	.1755	.583	.2008	.1359
Presque Isle (101–119)	12	.468	.731	.871	.1284	.591	.1850	.1146
Beaver Drainage (79, 62–78)	12	.459	.757	.873	.1264	.605	.2422	.1060
Presque Isle (101–119)	12	.468	.731	.871	.1284	.591	.1850	.1146
Allegheny tributaries (22–34)	12	.426	.806	.8372	.1627	.546	.1873	.1271
Presque Isle (101–119)	12	.468	.731	.871	.1284	.591	.1850	.1146
Beaver River (79)	12	.435	.648	.823	.1811	.468	.1708	.1379
Presque Isle (102–119)	12	.468	.731	.871	.1284	.591	.1850	.1146
French Creek (22–34)	12	.432	.805	.8457	.1540	.547	.1934	.1350
COMPARISON *Elliptio dilatatus sterkii*, LAKE ERIE DRAINAGE.								
Lake Erie, La Plaisance Bay	6	.3159	.525	.826	.1674	.576	.1504	.1225
Presque Isle Bay	6	.315	.494	.806	.188	.560	.1333	.1071
Elliptio dilatatus, COMPARISON UPPER OHIO DRAINAGE WITH LAKE ERIE.								
La Plaisance Bay (98)	6	.3159	.525	.826	.1674	.576	.1504	.1225
Presque Isle (101–120)	6	.315	.494	.806	.188	.560	.1333	.1071
Presque Isle (101–120)	31	.3119	.498	.807	.187	.542	.1656	.1025
Allegheny tributaries (22–34)	31	.283	.496	.778	.2196	.521	.2093	.1128
Presque Isle (101–120)	31	.3119	.498	.807	.187	.542	.1656	.1025
Beaver Drainage (60–79)	31	.283	.501	.768	.2316	.5381	.1898	.0993
Presque Isle (101–120)	31	.3119	.498	.807	.187	.542	.1656	.1025
Allegheny River (5–20)	31	.2906	.4917	.7825	.2503	.496	.1904	.1156
Presque Isle (101–120)	14	.315	.492	.808	.1204	.5400	.1077	.1320
Beaver River (79)	14	.2425	.4575	.783	.215	.507	.1591	.1461
COMPARISON *Symphynota costata eriganensis*, LAKE ERIE DRAINAGE.								
Lake Erie, Monroe County, Mich.	5	.307	.552	.764	.233	.498	.1826	.0876
Presque Isle Bay	5	.354	.560	.763	.240	.540	.215	.0853
Symphynota costata, COMPARISON UPPER OHIO DRAINAGE WITH LAKE ERIE.								
Presque Isle (99–120)	15	.363	.584	.809	.257	.584	.234	.0890
Allegheny tributaries (22–34)	15	.275	.583	.768	.231	.481	.2227	.0901
Presque Isle, Lake Erie (101–120)	18	.336	.550	.757	.242	.535	.2128	.0848
Beaver Drainage (60–85)	18	.270	.552	.727	.270	.476	.2101	.0920
COMPARISON *Anodonta grandis footiana*, LAKE ERIE DRAINAGE.								
Lake Erie, La Plaissance Bay	5	.311	.637	.673	.316	.444	.281	.0713
Lake Erie, Cedar Point	3	.404	.571	.693	.306	.442	.2072	.0418
Lake Erie, Presque Isle Bay	5	.383	.520	.752	.245	.446	.330	.1039
Maumee River, Roche LeBoeuf Rapids, Miami & Erie Canal	5	.388	.572	.732	.258	.377	.266	.0765

TABLE IV.—*Continued.*

Anodonta grandis, COMPARISON UPPER OHIO DRAINAGE WITH LAKE ERIE.

	No. Spec.	$\frac{DSD}{L}$	$\frac{DVD}{L}$	$\frac{PD}{L}$	$\frac{AD}{L}$	$\frac{PHL}{L}$	$\frac{AHL}{L}$	$\frac{TH}{DVD}$
Tributaries, Lake Erie (139–140)	8	.383	.582	.743	.265	.378	.253	.0255
Presque Isle (99–120)	8	.396	.537	.747	.251	.441	.252	.0793
Presque Isle (99–120)	6	.402	.562	.734	.264	.442	.263	.0964
Monongahela tributaries (6, 9)	6	.345	.577	.727	.272	.380	.2584	.0620
Presque Isle (99–120)	14	.375	.551	.719	.278	.445	.2404	.0797
Allegheny tributaries (22, 34, 45)	14	.372	.567	.695	.296	.384	.221	.0522
Presque Isle (139–140)	15	.367	.542	.765	.243	.449	.2442	.0833
Beaver Drainage (60–85)	15	.361	.557	.737	.260	.393	.229	.0549
COMPARISON *Anodontoides ferussacianus*, UPPER OHIO DRAINAGE.								
Shenango River, Linesville	6	.381	.543	.732	.271	.391	.242	.0518
Shenango River, Greenville, Sharpsville	6	.360	.574	.708	.293	.319	.198	.0517
Paraptera fragilis, OHIO RIVER DRAINAGE.								
Allegheny River: Kelly, Godfrey, Aladdin	4	.333	.818	.772	.227	.562	.213	.0492
Ohio River: Dead Man's Island & Edgeworth	3	.312	.653	.736	.263	.417	.218	.0531
Ohio River: Beaver	3	.340	.680	.720	.283	.467	.225	.0500
Ohio River: Industry	5	.304	.707	.712	.294	.437	.1894	.0522
Ohio River: Cook's Ferry and Smith's Ferry	5	.325	.685	.742	.261	.469	.216	.0538
Ohio River	4	.305	.683	.727	.275	.469	.214	.0522
Paraptera fragilis, LAKE ERIE DRAINAGE.								
Lake Erie, La Plaisance Bay	6	.315	.686	.739	.261	.543	.1970	.0517
Lake Erie, Presque Isle Bay	6	.322	.730	.764	.2430	.514	.1851	.0509
Paraptera fragilis, COMPARISON UPPER OHIO DRAINAGE WITH LAKE ERIE.								
La Plaisance (98)	7	.316	.681	.743	.258	.535	.2003	.0515
Presque Isle (99–120)	7	.337	.735	.721	.281	.506	.2176	.0491
All Lake Erie (98–124)	20	.339	.716	.738	.263	.518	.2111	.0619
Ohio Valley (1–59)	20	.323	.708	.736	.265	.470	.2123	.0516
Presque Isle (101)	4	.361	.753	.726	.273	.514	.2059	.0495
Allegheny River (15–16)	4	.333	.818	.772	.227	.562	.213	.0492
Proptera alata, LAKE ERIE DRAINAGE.								
La Plaisance Bay	8	.371	.850	.814	.330	.598	.1956	.0874
La Plaisance Bay	5	.329	.796	.723	.273	.525	.1948	.0591
Cedar Point, Lake Erie	5	.391	.811	.705	.295	.550	.2221	.0645
Presque Isle Bay	8	.379	.789	.708	.292	.536	.218	.0848
Maumee River, Roche de Boeuf Rapids	5	.345	.654	.731	.267	.539	.1751	.094

TABLE IV.—*Continued.*

Proptera alata, COMPARISON UPPER OHIO DRAINAGE WITH LAKE ERIE.

	No. Spec.	$\frac{DSD}{L}$	$\frac{DVD}{L}$	$\frac{PD}{L}$	$\frac{AD}{L}$	$\frac{PHL}{L}$	$\frac{AHL}{L}$	$\frac{TH}{DVD}$
Allegheny River (12, 14, 15)	8	.345	.740	.713	.285	.563	.2327	.0991
Presque Isle (99–119)	8	.379	.789	.708	.292	.536	.218	.0848
Ohio River (55–56)	14	.310	.809	.664	.335	.558	.2142	.0960
Lake Erie (99–102)	14	.404	.807	.709	.290	.555	.222	.0769
La Plaisance (98)	6	.315	.686	.739	.261	.543	.1470	.0517
Presque Isle (101–119)	6	.322	.730	.764	.2430	.514	.1851	.0507
Presque Isle (101–119)	4	.430	.825	.710	.289	.575	.226	.0690
Monongahela River (51)	4	.314	.766	.668	.330	.575	.184	.0825
COMPARISON *Anodontoides ferussacianus subcylindricus*, LAKE ERIE DRAINAGE.								
Lake Erie, Presque Isle	5	.366	.515	.719	.280	.413	.214	.0550
Maumee Drainage	5	.364	.566	.728	.268	.396	.233	.0626
Anodontoides ferussacianus, COMPARISON UPPER OHIO DRAINAGE WITH LAKE ERIE.								
Beaver tributaries (60–66, 62, 69)	6	.374	.541	.721	.325	.381	.225	.0563
Presque Isle (99–120)	6	.364	.513	.723	.278	.412	.222	.0564
Presque Isle (99–120)	8	.366	.511	.728	.272	.435	.223	.0572
Lake Erie tributaries (139–140)	8	.377	.576	.722	.276	.378	.229	.0514
Presque Isle (99–120)	7	.369	.517	.726	.274	.431	.227	.0538
French Creek Drainage (22–34)	7	.390	.630	.689	.320	.436	.2530	.0636
Presque Isle (99–120)	7	.369	.519	.726	.274	.431	.227	.0538
Beaver Drainage (60–85)	7	.333	.494	.728	.254	.336	.209	.0530
Presque Isle (99–120)	12	.334	.497	.675	.343	.406	.199	.0497
Shenango Drainage (61–69)	12	.370	.558	.720	.282	.355	.220	.0518
Eurynia recta, LAKE ERIE DRAINAGE.								
La Plaisance Bay	2	.260	.40	.816	.184	.572	.1367	.1220
Cedar Point	3	.247	.375	.773	.226	.500	.1476	.1187
Presque Isle Bay	3	.267	.424	.760	.236	.570	.1680	.1332
Maumee River, Station Pond Rapids	2	.262	.423	.765	.233	.475	.164	.180
Eurynia recta, COMPARISON UPPER OHIO DRAINAGE WITH LAKE ERIE.								
Presque Isle, Lake Erie (98–124)	15	.284	.389	.783	.2169	.555	.1587	.1239
Allegheny tributaries (22–34)	15	.263	.419	.783	.210	.518	.1852	.1592
Presque Isle, Lake Erie (98–124)	15	.284	.389	.783	.2169	.555	.1587	.1239
Allegheny River (10–17)	15	.260	.325	.834	.1756	.526	.1328	.1507
Presque Isle, Lake Erie (98–124)	15	.284	.389	.783	.2169	.555	.1587	.1237
Ohio River (55–56)	15	.308	.436	.834	.1727	.593	.1976	.1846
Lampsilis luteola rosacea, LAKE ERIE DRAINAGE.								
La Plaisance Bay, Monroe Co., Mich.	7	.393	.579	.731	.266	.515	.205	.1757
Cedar Point	7	.395	.584	.755	.248	.540	.219	.1160
Presque Isle Bay	7	.474	.603	.752	.245	.510	.233	.0994
Port Colborne, Ontario	3	.339	.619	.733	.266	.564	.207	.2082

TABLE IV.—*Continued.*

Lampsilis luteola rosacea, LAKE ERIE DRAINAGE.—*Continued.*

	No. Spec.	DSD / L	DVD / L	PD / L	AD / L	PHL / L	AHL / L	DVD / TH
Lake Erie, Port Dover	5	.417	.609	.712	.285	.527	.2217	.1260
Blanchard River, Hancock Co., Ohio	3	.334	.589	.752	.248	.489	.2078	.1236
Maumee River, Roche de Boeuf Rapids	3	.391	.543	.755	.243	.519	.203	.1533
Silver Creek, Williams Co., O.; Maumee River, Roche de Boeuf Rapids, Beaver Creek, Williams Co., O.; Swan Creek, Lucas Co., O.	7	.379	.607	.713	.289	.498	.221	.1277
Ten-Mile Creek, Toledo, O.	4	.373	.575	.718	.275	.489	.246	.134

Lampsilis luteola, COMPARISON UPPER OHIO DRAINAGE WITH LAKE ERIE.

La Plaisance, Cedar Point (98–99)	17	.377	.585	.740	.273	.509	.2216	.1229
Presque Isle (101–120)	17	.419	.588	.738	.2987	.516	.2217	.1046
Presque Isle (101–120)	15	.388	.567	.741	.259	.515	.2231	.1034
Conneaut Lake (27–31)	15	.374	.585	.747	.255	.511	.208	.1235
Presque Isle (101–120)	17	.419	.588	.738	.2487	.516	.2217	.1046
French Creek Drainage (22–34)	17	.375	.577	.737	.263	.494	.2261	.1262
Presque Isle (101–120)	8	.386	.578	.744	.258	.521	.2219	.1171
Monongahela (45–46)	8	.444	.517	.756	.245	.548	.217	.163
Presque Isle, La Plaisance Bay (98–119)	28	.397	.587	.743	.263	.506	.2206	.1136
Beaver Drainage (60–85)	28	.373	.589	.726	.272	.504	.2304	.1314
Presque Isle (101–120)	12	.431	.596	.754	.2441	.516	.221	.1051
Allegheny River (12–17)	12	.315	.583	.731	.265	.516	.273	.1508

Lampsilis ovata Canadensis, LAKE ERIE DRAINAGE.

La Plaisance Bay	2	.387	.673	.664	.335	.412	.225	.1424
Cedar Point	8	.544	.783	.713	.257	.434	.244	.0867
Lake Erie, Vermilion Co.	2	.489	.730	.714	.284	.453	.266	.0810
Lake Erie, Port Dover	3	.495	.764	.715	.283	.473	.1710	.0754
Port Rowan, Canada	2	.498	.775	.783	.217	.478	.247	.119
Conneaut Creek, West Springfield	2	.455	.721	.702	.300	.439	.215	.0918

Lampsilis ovata, COMPARISON UPPER OHIO DRAINAGE WITH LAKE ERIE.

Lake Erie (98–100)	12	.504	.763	.709	.290	.432	.23	.1038
Presque Isle (101–119)	12	.485	.752	.685	.318	.444	.2104	.0895
Allegheny tributaries (4, 22–34)	17	.463	.743	.693	.310	.459	.25	.0868
Presque Isle (101–119)	17	.486	.751	.677	.325	.437	.219	.0895
Presque Isle (101–119)	23	.482	.746	.680	.321	.434	.2202	.0856
Allegheny River (7–17)	23	.456	.705	.699	.276	.420	.206	.1011
Presque Isle (101–119)	12	.485	.752	.685	.318	.444	.2104	.0895
Beaver Drainage (60–85)	12	.442	.648	.682	.316	.439	.2321	.1049
Presque Isle (79)	9	.487	.761	.676	.328	.438	.198	.0909
Beaver River (79)	9	.445	.705	.652	.348	.403	.2127	.0665
Presque Isle (101–119)	5	.472	.758	.686	.316	.446	.1953	.0918

4. Correspondingly, the posterior hinge-length (*PHL*) tends to have a greater development in Lake Erie, and, as observed in the table, is apparently positively correlated with the posterior development of the shell. The converse appears to be established, *i.e.*, that the anterior hinge-length is best developed in the Upper Ohio, etc., and also positively correlated with the greater anterior development of the shell.

5. Thickness, as a rule, is greater outside of Lake Erie.

We have seen that the ancestors of the Lake Erie and Upper Ohio forms were derived from the same stock. Since some of the latter went over into the lake and became modified, the problem this investigation tries to answer is "How have they changed?" *The answer is given in the preceding paragraphs.* If we put a shell in the *lake environment* we may expect it will change its morphological features, not at random, but in a distinct, determinate, or orthogenetic direction, as is now seen by the fact that other shells behave the same way.

IX. CORRELATIONS.

From Tables IV and V also the following correlations may be derived in the case of shells from Lake Erie:

1. A decided tendency toward a greater degree of inflation (*DSD*) width, associated with less dorso-ventral diameter (*DVD*) height.

2. In all but two species (to which there are exceptions) there is a greater degree of inflation associated with greater posterior development of the shell (*PD*).

3. In all but two species greater posterior diameter is associated with greater posterior hinge-length.

4. Greater *DSD*, *PD*, *PHL*, and less *DVD* are associated with less thickness.

5. These dimensions correlate with one another throughout the lake environment.

With regard to the Upper Ohio shells the following seems true, viz.:

1. A decided tendency toward a less degree of inflation associated with a greater height and length of shell.

2. Less degree of inflation with a greater anterior development.

3. In most species, greater anterior development with greater length of anterior hinge-line.

4. Less *DSD*, greater *DVD*, *AD*, *AHL*, associated with greater thickness.

5. These dimensions correlate with one another throughout the environment.

Anticipating to a certain extent results obtained in another investigation, it may be said, that if, measurements from shells collected from all parts of the Ohio Valley (rather than those solely from the headwaters) be compared with those from Lake Erie, the Lake Erie shells are distinguished by their almost perfect correlation of dimensions as above, as distinguished from the negative aspects evinced by the polymorphic Upper Ohio forms, coming really, as I hope I have shown, from a variety of environments rather than a single fairly constant one. *Uniformity in environment, therefore produces a uniformity of effect upon these species of Naiades in most cases.*

X. Suggestions as to Causes of Facts.

It is thought well to again give a short summary of the physical and biological conditions present in Lake Erie and the Upper Ohio Drainage as they appear to be concerned with the *Naiades.*

Lake Erie.	Upper Ohio Drainage.
Water colder than in Upper Ohio, but with more even regulation of temperature. Currents much less rapid than in streams; water less agitated, except by moderate currents as indicated; carrying but little sediment. Bottom composed of pebbles, sand, or mixture of these, depending on region of lake, with coarser sediment derived from wear of land. Temperature conditions favor a more uniform production of food, while the water contains more lime.	*Water warmer than Lake Erie, greater extremes of temperature. Streams more rapid than currents of Lake Erie and more greatly agitated; frequent falls and rapids; short stretches of quiet pools. Rivers carry a load of debris which moves quickly over bottom, consisting of mud, glacial till, cobbles. Food conditions (due to extreme of temperature), are less stable, even if at times more abundant.*

Remarks and Suggestions Concerning Results Obtained.

(*a*) *On Inflation of Shell.*

Mr. Calvin Goodrich in a letter to the writer (1916), remarks that when colonies of shells are found in the lake, the members are sometimes moving about. Ordinarily, he states, it is not the usual thing for Unios to wander. This is indeed more frequently the case in spring when changing conditions impel migration, or at times when water becomes low in streams. We have seen that the *Naiades* of Lake Erie as a rule have a higher degree of inflation than those of the

Upper Ohio where the rapidity of the water is greater. It might seem that a shell having an exceptional degree of inflation would be at disadvantage in the short periods during which it might require to move about, for such would offer a greater surface to the water resulting in the impediment of its motions, let alone the obstruction the shell might encounter from a rocky bottom. In the lake, where there is little agitation of the water it might freely expand with less danger to itself. I feel there is something more than speculation about this hypothesis, inasmuch as certain other unpublished observations tend to show that even in rivers the greater degree of inflation is found where the current is less, as is also indicated in the resumé of the literature. As to the exception of *A. ferussacianus*, there is no clue whereby its exception to the law of inflation may be explained. Dr. Ortmann says: "It prefers small streams with sandy bottom and little current, frequently going into lakes." This statement of its favorite life conditions largely recalls Lake Erie. In the years of Dr. Ortmann's collecting (1909–18) he has obtained few or none of this species from the big rivers. Being somewhat primitive in character, it may well have reached in many respects the limit of adaptation compatible with biological balance, and the lake environment does not require the extreme of variation for it in this respect. This has some substantiation in the fact that the tabulation shows it to reach its greatest development in the Upper Ohio Drainage.

As to the length of the shell, my results corroborate those of the European investigators, who claim that it would be a useful adaptation, when connected with other characters, under the conditions of the environment in streams.

(*b*) *On the Height of the Shell* (*DVD*).

It was stated in the conclusion that there was a tendency observed for the shells as a whole to be higher in the Ohio. This may be a compensation in growth for the decreased inflation mentioned, or it might be more useful in getting about through the coarser gravel and mud, just as the shape of the more rapidly swimming fishes enables them to cut the water. At any rate this corresponds well with greater length. *Fusconaja*, *L. ovata*, and the majority of *Proptera* were higher in Lake Erie, together with even numbers of other shells. *Fusconaja* burrows deeply in fine gravel and sand, loves small streams and running water, disliking rough bottom and favors bars of fine,

firmly packed gravel. Many of its favorable conditions are found in Lake Erie as may be observed. Possibly its most enjoyable condition is found in a lucustrine environment, as indicated by the tabulation, which shows that of seven dimensions taken, five are greater there. *Proptera* is a lively shell, crawls about much, likes a steady current with rocks, gravel, and sand firmly packed. It would seem a greater height is more useful to it in moving about the rivers with their conditions than in Lake Erie. Here paucity of material compelled me to use that of the Ohio and I am uncertain as to the conclusions to be drawn, at least with regard to their stability. *L. ovata ventricosa* likes quiet pools and eddies, gravel partly covered with mud. Here again difficulty with material arises. *L. ovata* passes upstream into *L. ovata ventricosa*. To what extent this took place in my material, and what precisely the differences were, there was no way of telling, due to the puzzling intergrades. Mr. Goodrich states that in Lake Erie this mussel has a trick of burrowing completely below the surface and passes its gills fan-like from the shell, in which case the height of the shell might facilitate the burrowing process. However, other species do the same. Wilson and Clark (54) remark that this mussel becomes smaller towards the lakes, and perhaps we have here another evidence of compensatory growth. Specimens of *L. ovata* from "big rivers" are higher than those of the lakes.

(*c*) *On the Comparative Size of the Anterior and Posterior Portions of the Shell.*

It will be remembered that shells from the Upper Ohio were found to be better developed anteriorly and less posteriorly than those of Lake Erie. The need of sometimes having to move against opposite and unfavorable influences is met in the *Naiades* by the development of a foot, situated anteriorly. The physical nature of conditions in Lake Erie offer less impediment to such movements. Thus it may happen that the greater use of the foot in the Ohio would result in its greater enlargement, and have an ultimate effect in the development of the shell covering it. Such hypothesis could only be proven experimentally, inasmuch as other factors may be concerned. Sell found that the anterior part of the shell was best developed in rivers, and from the results of another investigation I may state that in the Monongahela, where conditions more closely resemble those of Lake

Erie than those of the headwaters, shells of the same specific stock have the posterior part better developed than forms from the tributaries. Conditions are more regular in Lake Erie, but the impulse to migrate less frequent, and if there be such a thing as adaptation, enlargement of foot correlated with enlargement of shell apparently follows in the Upper Ohio. To the two exceptions, *Eurynia* and *L. ovata*, the following remarks may apply. The former appears to enjoy coarse or fine gravel in a strong current in large and moderate rivers, never small streams, and often burrows deeply. Under these conditions, if the hypothesis of modification of shell holds true, we should expect to find a greater development of the anterior portion, which we do not. Apparently, the only consistent explanation is to suppose it requires a smaller foot for burrowing than in moving against the current in the Upper Ohio. Possibly the compression of shell may account to some extent for this. In this connection it may be pointed out that *Proptera* and *Paraptera*, both active shells, show by my evidence that they may, or may not, have this portion of the shell developed, in either environment. March may be quoted in this connection on the growth of *Naiades*, "anterior growth is slower than the posterior, as is natural in the case of an animal which has to plough its way through the mud. An increase in current in which they live would produce decrease in preumbonal development and so tend to throw the umbo forward in those forms living in strong currents. Forms with umbo thrown forward are found in canals having strong gradients." With regard to *L. ovata*, to which there are some exceptions, nothing I have found may be related to the morphological facts, except that shells from Lake Erie may be unmodified descendants of more strenuous ancestors. Some hypothesis of evolution might support this. Remembering Wilson & Clark's observation, it may be associated with food conditions. Still a tendency toward greater anterior development may be seen in Table III—where *Eurynia*, *L. ovata*, and *Paraptera* are equally divided in the number of cases showing superior development of the anterior hinge-line.

(*d*) *On the Length of the Posterior and Anterior Hinge-lines.*

As the posterior hinge-lines join the posterior portions of the shell, we should xpect to find them best developed in the localities where these are best developed. This seems to be a reasonable correlation

to take from Table III. Correlations and observations on *Paraptera* are apt to be misleading for the reason stated. For this, however, a great deal one way or another can be inferred from the even number of cases mentioned. It follows that greater rigidity of the posterior portion of the shell is required in Lake Erie; *vice versa* in the Ohio.

(*e*) *On the Thickness of the Shell.*

While Lake Erie contains more lime, it is evident that the great majority of shells are thinner there. It is known that the presence of CO_2 (44) in water tends to erode shells, yet far more of the finer shell architecture, such as beak-sculpture, seems to be preserved in specimens from Lake Erie than in those from the Upper Ohio Drainage. March states (30) that shells from districts highly charged with $CaCO_3$ have thin shells and are not eroded at the beaks. This may be attributed to the lack of humic acid, which does not occur where limestone is. Greater thickness of shell seems to be connected with presence of humic acid, or absence of chalk. Dr. Ortmann noted the presence of humic acid in the Shenango, the water supply of which is largely derived from swamps containing peat and decaying vegetable matter. This explanation of March's does not correlate with my measurements in the case of *Anodonta*, *Pleurobema*, *Elliptio* in the Shenango, although it does in the case of other species. With regard to marine Pelecypoda, Baker (4) observes that the thinness of shells in the Caspian Sea appears to be directly correlated with the degree of saltiness of the water. It is safest to assume that each shell takes what lime it needs under the circumstances. Rich (41) tells of some shells from a soft water lake in New York, which were almost free from lime.

It is thought that perfect uniformity in these results has not been obtained because of:

1. Lack of sufficient material in species, the variability of which may be unusually great.

2. Ecological habits of species, which may play a larger part than we now know.

Sources of Error.

With a reasonable amount of care the rapid measurement of these dimensions was not inconsistent with accuracy, with the sole exception of that of the length of the hinge. This seemed to be too important a character to neglect, yet often it had to be estimated by the eye where

the line was too curved to measure directly. In certain species the work was easier than in others, but, because the results appear to be uniform throughout, I am confident that no serious mistake was made.

I have given at some length a detailed differential description of those environments, the *Naiades* of which we have compared. With the change of environment from the river to the lake there is seen to be a *parallelism* in the change of the morphological character of the shell. As pointed out previously, shells from Lake Erie are as a rule smaller, have broader growth-lines, brighter colors, and more polished epidermis, and are thinner than those of the Upper Ohio. Still specimens from many parts of the Upper Ohio could, even in these respects, be confused with those of Lake Erie, as I found when describing new varieties from the lake (14). This necessitated careful measuring for their accurate determination, leading into the investigation I have here attempted. It will be observed that this paper merely extends the similar work carried on by systematists, and deduces certain laws stated in the conclusions. And of all theories of evolution advanced, Lamarckian factors perhaps account for these changes better than any others. Moreover the principle stated by Sell (45)—*that the size of Unios seems to be proportionate to the size of the body of water in which they are found*—finds strong substantiation in my results as does the important principle first stated for Mollusca by Haas and Schwarz (15) viz: "*The same original types change, under the same biological (ecological), conditions, into identical local forms: different original types change, under the same biological (ecological), conditions into convergent, (parallel) local forms. In consequence of sufficiently long isolation, the local forms may develop into constant local varieties.*"

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V. SOME FEATURES OF THE GEOLOGY OF NORTHEASTERN BRAZIL.

By Gerald A. Waring.

(Plates IV–X.)

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By W. J. Holland

Introductory.

During the years 1910–1913 the writer was engaged in reconnaissance work for the Brazilian Government, seeking to ascertain the possibility of storing supplies of surface-water and developing ground-water supplies in the arid northeastern portion of that country. Although observations of the geology along the routes traversed were in many places unsatisfactory because of the exigencies of the main

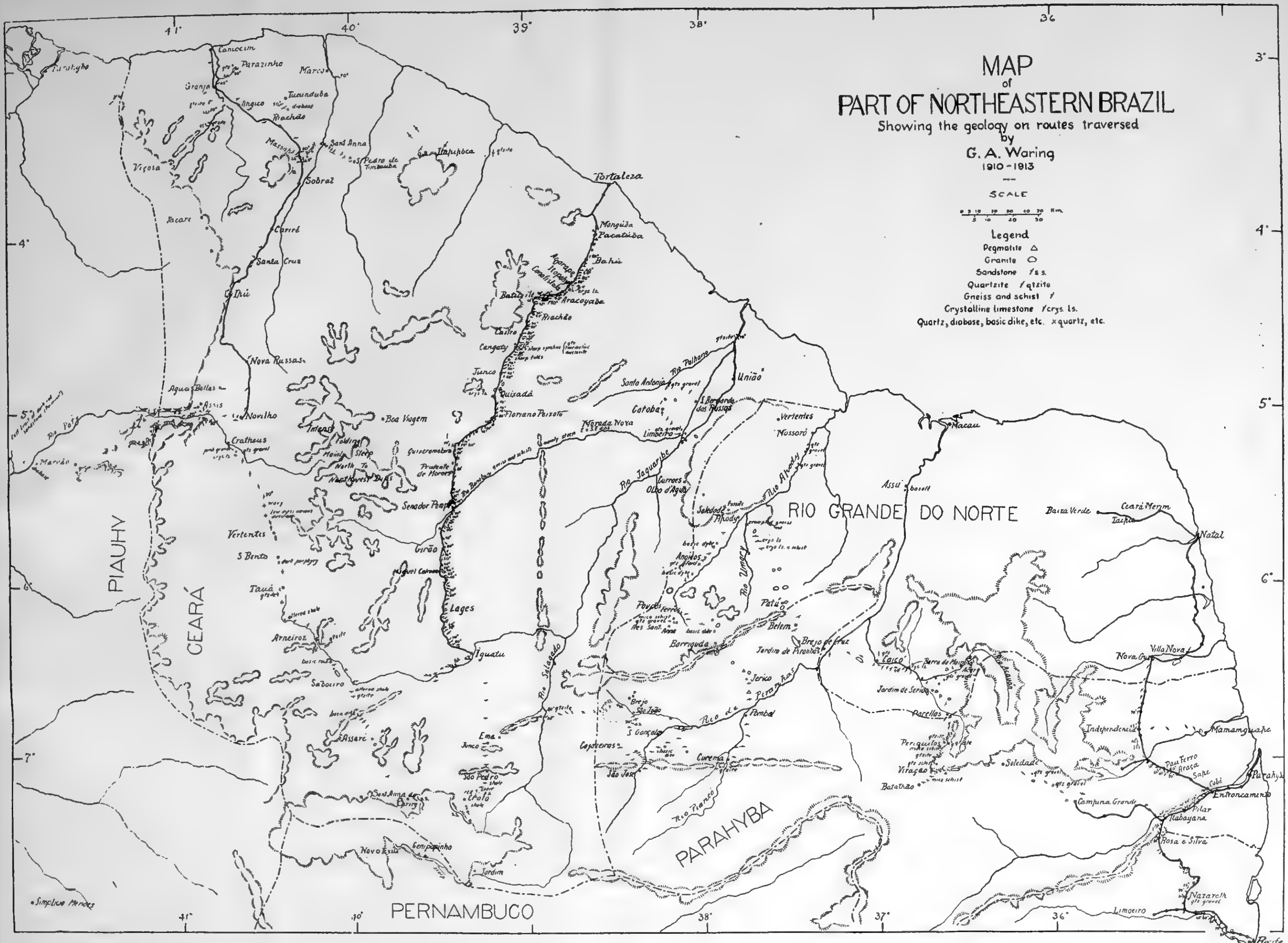
studies, several geologic problems developed, which it is believed worth while to set forth, together with such data as were obtained concerning them. The water studies involved journeys in two general areas, the northern one embracing parts of the states of Pernambuco, Parahyba, Rio Grande do Norte, and Ceará; the southern one being in the State of Bahia. The location of the region is shown on the index map, Fig. 1.

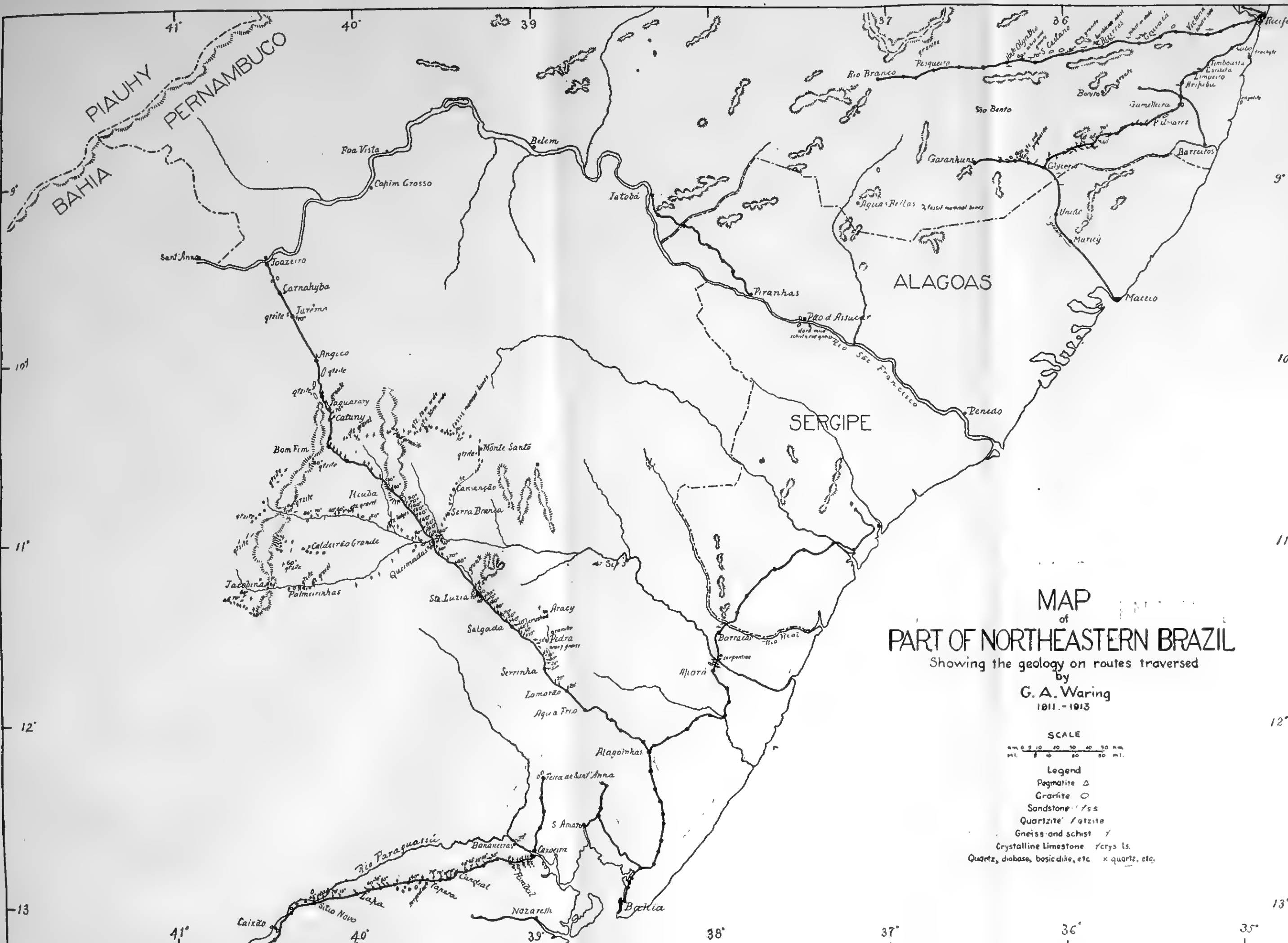
FIG. 1. Index Map of South America, showing location of the region under discussion.

As a whole this region constitutes a plateau, rising gently inland from the coast to mean elevations of 200 to 400 meters. There are no great mountain ranges, but numerous small ranges and isolated hills rise above the mean levels, and several tablelands rise to elevations of 600 to 900 meters above sea-level. The channels of the streams trend fairly directly to the coast, being almost throughout their courses wide and sandy, with low gradients. Most of the streams are dry during a great part of the year, for much of the region receives but uncertain rainfall and suffers from periodic droughts.

Geologically, the area as a whole has a basement series of gneiss and crystalline schists referred to by Dr. Branner as the Brazilian complex,[1] intruded by granite and by dike rocks and overlain by

[1] *Geologia Elementar*, by John C. Branner, 2d ed., Rio de Janeiro, 1914, p. 289.


MAP
of
PART OF NORTHEASTERN BRAZIL
Showing the geology on routes traversed
by
G. A. Waring
1910-1913
SCALE
Legend
Pegmatite △
Granite ○
Sandstone / s s.
Quartzite / qtzite
Gneiss and schist /
Crystalline limestone / crys. ls.
Quartz, diabase, basic dike, etc. x quartz, etc.
PIAUHY
CEARÁ
RIO GRANDE DO NORTE
PARAHYBA
PERNAMBUCO
Fortaleza
Sobral
Granja
Camocim
Viçosa
Ipú
Santa Cruz
Nova Russas
Crateus
Quixadá
Quixeramobim
Senador Pompeu
Lages
Iguatu
Boa Viagem
Aracoyaba
Baturité
Pacatuba
Mangúba
Cangaty
Floriano Peixoto
Morada Nova
Limoeiro
União
Vertentes
Mossoró
Macau
Assu
Natal
Ceará Mirim
Patú
Belem
Caicó
Jardim de Seridó
Parelhas
Soledade
Campina Grande
Mamanguape
Parahyba
Entroncamento
Pilar
Itabayana
Rosa e Silva
Nazareth
Limoeiro
Recife
Pombal
Souza
Cajazeiras
S. Gonçalo
São José
Curema
Piancó
Rio Jaguaribe
Rio Salgado
Rio de Piranhas
Rio Apody
Tauá
Arneiroz
Saboeiro
Assaré
São Pedro
Crato
Novo Exú
Jardim
Simplicio Mendes
Marcó
Sant Anna
Riachão
Massapê
Campo Grande
Independencia
Batalhão
Villa Nova
Nova Cruz
Pau Ferro
Cobé
Sapé
Pirpirituba
Sant Anna do Cariry
Ema
Junco
Barra de Maxiniano
Jerico
Brejo de Cruz
Jardim de Piranhas
Pau dos Ferros
Apodi
Soledade
Anjicos


MAP
of
PART OF NORTHEASTERN BRAZIL
Showing the geology on routes traversed
by
G. A. Waring
1911–1913
SCALE
Legend
Pegmatite
Granite
Sandstone
Quartzite
Gneiss and schist
Crystalline Limestone
Quartz, diabase, basic dike, etc.
PIAUHY
PERNAMBUCO
BAHIA
ALAGOAS
SERGIPE
Recife
Maceio
Bahia
Joazeiro
Sant'Anna
Carnahyba
Angico
Jaguarary
Catuny
Bom Fim
Monte Santo
Serra Branca
Caldeirão Grande
Jacobina
Palmeirinhas
Queimadas
Sta Luzia
Aracy
Salgada
Serrinha
Alagoinhas
Feira de Sant'Anna
S. Amaro
Cachoeira
Bananeiras
Nazareth
Caixão
Sitio Novo
Rio Paraguassú
Belem
Boa Vista
Capim Grosso
Jatobá
Piranhas
Pão d'Assucar
Rio São Francisco
Penedo
Garanhuns
Glycerio
Barreiros
Rio Branco
Pesqueira
São Bento
Aguas Bellas
Murucy
Barracão
Alagoinhas

sedimentary rocks, which probably range in age from early Paleozoic to Tertiary. The succession of rocks in Bahia has been discussed by Branner and Crandall[2] and by Soper.[3]

The succession of rocks in the northern area, in which most of the writer's observations were made, have been discussed by Crandall,[4–5] Soper[6–7] and Small.[8–9]

The approximate areal extent of the several geologic formations have been delineated on maps prepared by these geologists for the Brazilian Government; and their data, together with those of himself and others, have been brought together on one map by Dr. J. C. Branner.[10] Geologic boundaries along routes traversed are shown in a few places on the accompanying maps (Cf. Plates IV and V), but the data presented on these maps are primarily of the bedrock structure, with observed occurrences of diabase, pegmatite, and other rocks of minor areal extent.

In the northern area a horseback trip was made by the writer from Campina Grande westward to Therezina (on the Parahyba River), and the principal railroad lines were traversed in 1911 between

[2] *Preliminary Report on the Geology of Portions of Bahia, Sergipe, and Alagôas*, by John C. Branner and Roderic Crandall. (Manuscript report of the Brazilian Geological Survey.)

[3] *Geologia e supprimento d'agua subterranea em Sergipe e no nordeste da Bahia, pelo Engenheiro Ralph H. Soper.* (Publication No. 34 of the *Inspectoria de Obras Contra as Seccas*, Rio de Janeiro, 1914, pp. 17–45.)

[4] *General Notes on Northeastern Brazil*, by Roderic Crandall. (Manuscript report of the Brazilian Geological Survey, 1908.)

[5] *Geographia, Geologia, Supprimento d'Agua, Transportes e Açudagem nos Estados Orientaes do Norte do Brazil (Ceará, Rio Grande do Norte, Parahyba)*, por Roderic Crandall. Publication No. 4 of the *Inspectoria de Obras Contra as Seccas*, Rio de Janeiro, 1910, pp. 21–34.

[6] *Geologia e Supprimento d'Agua Subterranea no Rio Grande do Norte e Parahyba*, pelo Engenheiro Ralph H. Soper. Publication No. 26 of the *Inspectoria de Obras Contra as Seccas*, Rio de Janeiro, 1913, pp. 18–30.

[7] *The Geology of Parahyba and Rio Grande do Norte, Brazil*, by Ralph H. Soper. Proc. Am. Phil. Soc., Vol. LV, No. 1, 1916, pp. 1–20.

[8] *Geologia e Supprimento d'Agua Subterranea no Ceará e parte do Piauhy*, pelo Engenheiro Horatio L. Small. Publication No. 26 of the *Inspectoria de Obras Contra as Seccas*, Rio de Janeiro, 1913, pp. 25–48.

[9] *Geologia e Supprimento d'Agua Subterranea no Piauhy e parte do Ceará*, pelo Engenheiro Horatio L. Small. Publication No. 32 of the *Inspectoria de Obras Contra as Seccas*, Rio de Janeiro, 1914, pp. 29–58.

[10] *Geologic map of Brazil* by John C. Branner, in the press by the Geological Society of America.

Camocim and the southern terminus at Novilho, between Fortaleza and Iguatú, and the coastal lines between Natal and Maceió. In the southern area horseback trips were made in the basin of the Itapicurú River, and the railroad lines between Bahia and Joazeiro, Bahia and João Amaro, and Bahia and Feira de Sant' Anna, were traversed.

GEOLOGIC FEATURES TREATED.

The geologic features in the north which principally attracted the attention of the writer are the following:

1. Structure in the basement series, as indicated by the strike and dip in the foliation planes of gneiss and schists.
2. The Ceará Series of ancient sedimentary rocks; its characteristics and distribution.
3. Granite, in its relation to gneiss and schists.

In the southern area the same features are of note, with the substitution of the Minas Series of quartzites and schists for the Ceará Series.

Minor features, noted throughout the region, which seem to be of some geologic importance, are: The widespread occurrence of partially rounded quartz gravel; the uncommon occurrence of basic igneous rocks, and the scarcity of springs.

STRUCTURE.

With the areal discussion of structure in the basement-series it is convenient to combine the notes on structure in the Ceará Series, for, so far as has been observed by the writer and by others, the structure in these ancient sedimentary beds is conformable with that of the gneiss and schist. Indeed, in a number of places the schist may be a member of the sedimentary series. The trends of granitic masses and of pegmatite dikes have also been mentioned in the areal treatment of the structure.

From Campina Grande Westward. In the vicinity of Campina Grande the gneiss is rather deeply disintegrated, but where well exposed it shows uniform strike about N. 70° W., true. Numerous small dikes of pegmatite traverse it in various directions, and hornblende gneiss, which easily cleaves into slabs, is used for flagging. The constant strike and steep dip continue northwestward throughout nearly all the distance to Soledade. Pegmatite dikes become less

common, but black tourmaline seems to be more in evidence in them. Knolls of granite or coarsely banded gneiss rise above the mean level. Westward from Soledade the strike of the gneiss swings slightly to nearly west, with steep south dip. Thirty kilometers from Soledade a small granite range trends N. 70° W., magnetic, or nearly west, true. West of this range some variation in the strike was observed, from about N. 60° W. to due west. Occasional pegmatite dikes seem to have the same strike as the gneiss. Schist, or perhaps finely laminated phases of the gneiss, also exhibit the same uniform strike, with steep south dip. Ten or 12 kilometers northeast of Batalhão thinly-foliated mica-schist, much disintegrated, produces an uneven topography. Seven or eight kilometers east of Batalhão a dark mica-schist, striking N. 60° W., and dipping steeply southward, forms prominent though small ledges, distributed over the surface so as to resemble gravestones. Toward Batalhão the material becomes coarser in texture, and near this town the principal rock is a porphyritic feldspar gneiss. At several places in the river near this place, ledges striking west extend nearly across the channel. The slopes on each side of the stream expose material of a more granitic texture. Northward a gently rolling plain of coarse-grained gneiss exhibits strikes of N. 70° W., to S. 70° W., with the usual steep south dip. A small stream fifteen kilometers from Batalhão has cut a deep valley in the mica-schist, which had been crossed by me farther to the east. More resistant gneiss is thence exposed at intervals to Viração. The road then crosses a small range of light-colored micaceous quartz-schist, which in places crumbles to sand and resembles a sandstone. Two kilometers east of the road a white ledge, seemingly of quartzite, dips northward at an angle of thirty degrees. In the lowland along the north base of the range dark-green gneiss strikes southwest, with steep southeast dip. Dark mica-schist, thinly foliated and carrying much quartz, is exposed in a low divide three kilometers southwest of Periquitos. Along the course of a small stream north of this place white quartzite seems to lie nearly horizontally over dark gneiss, which contains a green mineral, probably chlorite, and brown garnets up to three or four millimeters in diameter. Four kilometers north of Periquitos a small spring issues from beneath a prominent quartzite ledge, which strikes S. 25° W., with dip of thirty-five degrees westward. In the vicinity both quartzite and pegmatite form ledges in the gneiss area, as shown on Plate VI, fig. 1, which also shows what seems to be a quartzite-

capped tableland to the southwest. The principal pegmatite dikes strike S. 30° W., parallel with the valley of the stream, but minor ones branch off in various directions. Eight kilometers north of Periquitos the pegmatite carries much muscovite and black tourmaline. Farther northward the pegmatite is finer in texture and associated with mica-gneiss. On the east side of the valley the gneiss dips westward at forty to fifty degrees, but the dip seems to be less steep on the west side.

One kilometer south of Parellas dark mica-gneiss strikes S. 50° W., and nearby a prominent pegmatite ledge trends S. 35° W. Northwest from Parellas the gneiss continues with strike S. 50° W., and twelve kilometers from this village pegmatite again becomes common, many dikes cutting the gneiss with fairly constant southwest strike and vertical dip.

Three kilometers southwest of Jardim de Seridó agranitic or haplitic dike cuts southward across a river-channel, and two and one-half kilometers southeast of the town a pegmatite dike trends southwest across another stream-channel, as shown on Plate VI, fig. 2. About one hundred and seventy-five meters downstream from it a waterfall of three meters is formed by another granitic ledge, but the main country-rock is gneiss, with general southwest strike. In this are intruded areas of granite, which form isolated, half-barren hills. Crystals of muscovite mica as much as five or six centimeters in dimensions are plentiful in the pegmatite of the locality, but they are flecked with iron. Garnets up to one centimeter in diameter are also common, and some graphic granite was seen. To the northeast many pegmatite dikes cut the gneiss in all directions. About half-way between Jardim de Seridó and Acary the gneiss becomes more granitic in texture, and thence northward pegmatite is less common. At Acary the rock is granitic rather than gneissic, and at the Gargalheira dam site, a few kilometers to the northeast, it is a hard, fresh, porphyritic material. In the narrow stream-channel the boulders and bedrock are deeply worn into pits and potholes, as shown on Plate VII, fig. 1. For six or eight kilometers westward from Acary many pegmatite dikes cut the granite and gneiss, but farther west pegmatite is less common and decomposed gneiss becomes the predominant phase of the surface-rock. Near the junction of the Rios Acauan and Seridó, thirty kilometers southwest of Acary, the strike of the gneiss swings from the prevailing west or southwest to about S. 20° W., and pegmatite becomes scarce.

FIG. 1. Pegmatite dikes near Periquitos, Parahyba, with tableland, probably capped by quartzite, in the distance.

FIG. 2. Pegmatite dikes near Jardim de Seridó, Rio Grande do Norte; granite hills in the distance.

Well-bedded, gray, crystalline limestone forms a dam site at Barra do Mainoso, forty-seven kilometers from Acary. The principal exposure strikes S. 20° W., with a dip of forty degrees eastward. The eastern limit of the limestone is marked by a ledge in the channel of the stream, which has the same strike and dip as the main ledge, and by a ledge of gneiss one hundred and fifteen meters farther to the east in the channel, having conformable structure. Pebbles of iron oxide, some with prismoidal faces, are scattered over the surface of the gneiss for several hundred meters eastward from the limestone. To the west the limestone extends for about two kilometers, where gneiss reappears and becomes more granitic toward Caicó. Several large ledges which seemed to be of white quartz, but may be of pegmatite, cut the granitic gneiss northeast of Caicó. One ledge, striking south, forms a dam site on a small stream five kilometers north of the city. Northwest from Caicó the granitic gneiss contains considerable quartz along its foliation planes, which swing in strike from S. 20° E. through south to west. Ten or twelve kilometers northwest of Caicó there is a small granite hill; granite is also exposed in a stream-channel at Jardim de Piranhas; and Brejo da Cruz is at the western base of a prominent granite hill with steep, smooth, spalled-off slopes, the long axis of which trends N. 40° W. Thence northward the surface is granitic rather than gneissic. Two shallow intermittent ponds in this locality are worthy of mention, because even intermittent ponds are rare in the region and were observed only in granitic not in gneissic areas. The most notable occurrence of such ponds is two hundred kilometers to the northwest, between Quixeramabim and Prudentê de Moraes. If this observation is correct, it may be accounted for by the greater difficulty of underground drainage down through the granite, than down along the foliation planes of the gneiss. To and beyond Belem the surface of the plateau continues mainly granitic, though with some gneissic phases. Numerous granitic hills rise above the mean level. Patú is at the northwestern base of such a large hill. North from Patú there is a wide plateau of granite, containing feldspars from one to two centimeters in length. The illustration given on Plate VII, fig. 2, shows some of the granite hills a few kilometers north of Patú.

About halfway between Patú and Apody the rock becomes more banded and gneissic, and twenty-five kilometers southeast of Apody the road crosses a ledge of crumpled, siliceous-calcareous schist a few

meters thick, with a little crystalline limestone. The material strikes west, with steep south dip. A hillside one-half kilometer farther north is of cherty material, but schist and limestone appear again on the north side of the ridge, which seems to be part of a sharp anticline. Thence northward coarsely-banded gneiss appears, with nearly vertical foliation planes striking west; but the rock shortly becomes bouldery and granitic in character.

On the slope descending northward to Rio Umary there is pegmatite composed of vitreous quartz and pink feldspar, and quartz fragments are scattered over the surface of the decomposed gneiss. An alluvial area three kilometers wide borders the river in this locality, with crumpled gneiss on low slopes at the north border of the lowland. Between the Rios Umary and Apody the surface is covered with sand, which seems to be composed of angular fragments derived from disintegrated granite; but soft red sandstone, belonging to the Cretaceous series, is exposed along the north bank of Rio Apody, and the low slopes near Apody are covered with sand which is probably derived from this sandstone. For three or four kilometers northeast, downstream from Apody, the red sandstone continues; and thence downstream to Mossoró non-crystalline limestone, which overlies the sandstone conformably, forms cliffs, which border the river and dip gently coastward. Northwestward from Mossoró the surface rises gently up the limestone tableland to Vertentes, then lowers slightly to an escarpment, where the surface drops seventy meters to wide lowlands along the Rio Jaguaribe. The rock exposed across the tableland (Chapada do Apody), is wholly limestone, though it is partially covered in a few places with a film of sandstone and iron-cemented gravel, which is presumably a remnant of the coastal Tertiary materials. The scarp where descended exposes only limestone, but the underlying sandstone is in evidence in the river channel and adjacent low slopes.

At Passagem das Pedras on the Rio Jaguaribe at the upper limit of the tide, gneiss strikes N. 20° W., magnetic, or about N. 35° W., true, with dip of seventy degrees to the northeast. Between the river and the village there is a prominent ledge of white quartz, or possibly quartzite, for Serra Araré, situated two kilometers to the west, is composed in part of quartzite, with dip and strike apparently conformable with that of the gneiss in the river Conformable structure is also shown in gneiss, carrying much quartz, at the base of the serra.

From this serra, red-brown quartz-schist is obtained for flagging in Passagem das Pedras and União.

On crossing the valley of the Rio Jaguaribe and going northwestward from São Bernardo das Russas, deep, sandy soil covers the surface for several kilometers. Gneiss was seen in a reservoir eight kilometers northwest of the town, but the sandy soil continues for about four kilometers farther. Thence gneiss becomes more frequently exposed, with constant northwest dip, as far as Santo Antonio. From this place southward the rock is more granitic, with some bands of thick-banded gneiss. In a reservoir at Jatobá the bed-rock is well exposed, being granitic rather than gneissic in texture, yet exhibiting a wavy structure traversed by numerous veinlets. Four kilometers to the south pink granitic gneiss strikes north with vertical dip, and three kilometers farther south gneiss with steep southeast dip is exposed. The surface then becomes sandy, to the alluvial lowlands, about ten kilometers wide, near Limoeiro. Southeast of this city several granitic knolls rise ten to twenty meters above the level of the lowland; but no crystalline rocks were seen along the escarpment of Chapada do Apody, which borders the valley on the southeast. The limestone of this tableland rises southward so that whereas southeast of União it forms the entire escarpment, at Curraes it forms a capping only five meters thick upon the sandstone, which here composes the main part of the scarp. Southward across the highland there are several wide exposures of the bare limestone; but for the most part there is a thin soil, given a brown tone by iron-oxide gravel. In a few places masses of conglomerate, twenty or thirty centimeters in diameter, from which the gravel apparently is derived, were seen. Four kilometers north of Soledade the limestone for one hundred or two hundred meters carries plentiful turritella-like fossils. On the scarp descending to Apody the limestone is about twelve meters thick, being underlain by dark-red and blue-gray sandstone.

Southwest from Apody sand and sandstone cover the surface for several kilometers, with coarse gravelly sandstone, seemingly basal material, in evidence in a few places; but about ten kilometers from Apody, granitic gneiss is exposed. The foliation planes there lie nearly horizontally, but southward the dip rapidly steepens to a nearly vertical south dip. To and beyond Angicos the gneiss is cut by occasional veins of quartz and dikes of pegmatite. Near Angicos the strike swings to a little south of west, with steep southward dip.

The serras to the northwest and southeast of Angicos have nearly horizontal cappings of Cretaceous sandstone, but from near Angicos the underlying gneiss or schist seems to dip westward at twenty to thirty degrees. Halfway between Angicos and Paú dos Ferros the strike of the gneiss seems to swing from westerly to southerly. In the vicinity of Paú dos Ferros the rock seems to be mainly granitic gneiss, but no good exposures showing the strike were observed. For some distance to the southwest the rock seems also to be granitic gneiss; but six or eight kilometers from the city there is a belt of hornblende rock, succeeded by mica-schist. The gneiss also extends for some distance southeast of the city, but at the crossing of Rio Apody, seven kilometers away, the rock is extensively decomposed into a white kaolin-like clay. The strike here is nearly south, with steep west dip. A few kilometers to the east, however, the dip seems to swing to nearly north. Near reservoir Corredor, thirty-five kilometers southeast of Paú dos Ferros, the main rock is decomposed granitic gneiss, with a prominent granitic hill three kilometers to the southwest. Near the reservoir green (chloritic?) garnet gneiss was noted, and both there and at the base of the granite hill there is much hornblende. Thence southward the rock is granitic to and beyond Barriguda. Serra da Barriguda contains prominent, nearly barren granitic peaks, which give the range a markedly saw-tooth profile. Near the south base of the range the rock is very porphyritic, with feldspars up to two centimeters in length. Near Jericó the rock is more gneissic, with pegmatite dikes and a small amount of chlorite (?) schist. In the river channel a short distance north of the village a dark biotitic rock is exposed for two hundred meters. Thence to Pombal the rock is gneissic or schistose, with dikes of pegmatite and dark areas, which seem to be due to the segregation of hornblende and biotite. From Pombal to Curema the rock seems to be all schistose, the dip being to the north and increasing from about thirty degrees near Pombal to nearly vertical near Curema. The rock also becomes more thinly laminated as one approaches Curema. The range, composed of the serras of Vital, Santa Catharina, and Melado, forms a remarkably straight, east-west ridge, composed in part of white, granular quartzite, carrying muscovite. Near Curema the Rio Pianco cuts northward across the range and exposes the rock dipping nearly vertically southward. At Rio Aguiar, five kilometers west of Curema, there are apparently four ledges of quartzite, and it seems as if the range here

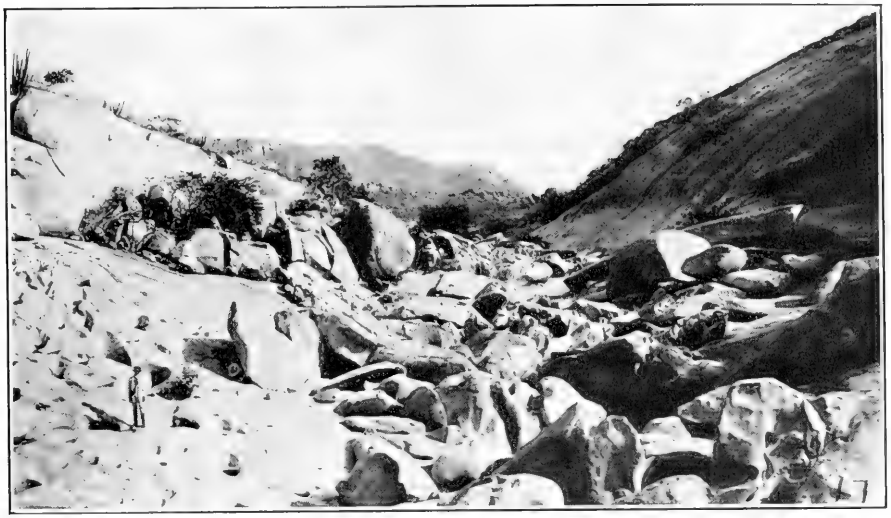


FIG. 1. Granite in the gorge of Rio Acauan at the Gargalheira dam site, Rio Grande do Norte.

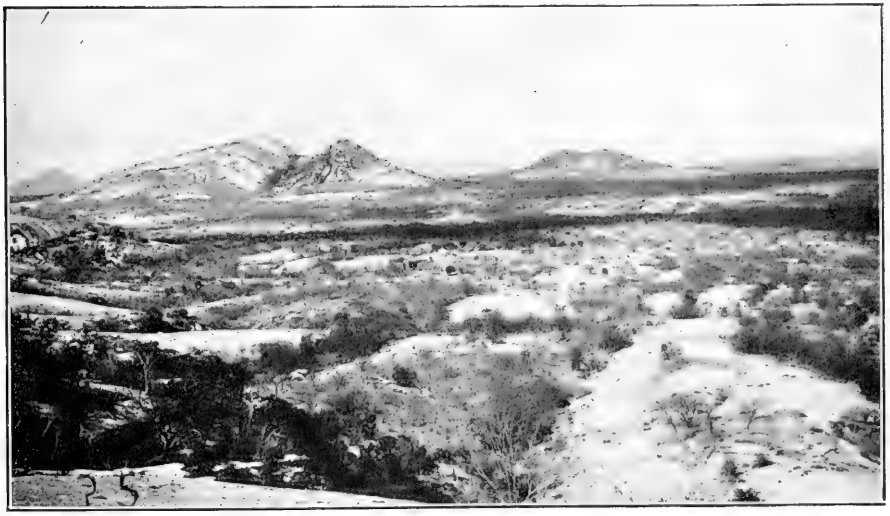


FIG. 2. Granite hills near Patú, Rio Grande do Norte.

as is less evidenced at Curema, were structurally a sharp anticline. In the canyon of the Rio de Piranhas, forty-five kilometers farther west, the quartzite is also well exposed, and, as in the other places, the range seems to be anticlinal. South of the range at Rio de Piranhas, however, the gneiss seems to dip steeply north, instead of to the south, as it should to conform to this structure; though a sharp syncline at the south base of the serra may account for this seeminp discrepancy.

From Curema northwestward past São José da Lagoa Tapada and across the small Serrinha Cascavel the gneiss has conetant west strike and steep north dip, and is cut by the usual quartz and pegmatite stringers. On the slope down nearly to Rio de Piranhas gneiss is exposed, dipping eighty degrees to the north; but sandstone, which occupies a considerable area in the basin of this river in the vicinity of São João and Souza, appears in a low cliff on the north side of the channel, and continues across the valley to the base of Serrinha Macaco, three kilometers north of Souza. Gravelly sandstone is there exposed at the edge of the valley, with hard, firmly cemented conglomerate a few meters higher up the slope, together with rock which resembles a feldspar porphyry, but may be a phase of the conglomerate. The higher slopes are of gneiss with some granitic phases. At São Gonçalo, at the border of the valley southwest of Souza, gneiss is exposed dipping steeply to the north. Large boulders of gneiss form a dam site on a small stream three kilometers to the south. Near Nazareth there are several prominent peaks of gneiss, of which Pico, capped by a perched boulder, is the most striking. Thence southward to Serra Santa Catharina only gneiss was observed. South of the range gneiss containing garnets is exposed at the river side at São José. Thence toward Cajazeiras the gneiss has nearly vertical north dip. In a few places questionable south dips may show some overturning or sharp folding. At Cajazeiras the gneise is well exposed, with steep north dip, in the spillway of the town reservoir. About twelve kilometers to the northeast, or one and one-half kilometers south of, and seventy meters above, the lowland of Rio do Peixe, there is a light-colored feldspathic rock, considerably kaolinized. It is possibly a phase of the basal conglomerate seen a few kilometers north of Souza; for at the border of the valley, the dark-red sandstone appears fifteen meters above the lowland, making sharp contact with the gneiss and dipping northeastward at an angle of thirty degrees.

Thence northward across the valley the sandstone forms two very low anticlinal ridges which are covered by a thin layer of soil.

The dam site Poço da Pedra, twelve kilometers north of São João, is formed by a sandstone ridge, but three kilometers farther north another dam site is formed by crushed, schistose rock. The material contains secondary quartz and resembles an altered sandstone. A large pegmatite dike forms a prominent ledge nearby. Near Brejo, ten kilometers north-northwest of São João the sandstone is gravelly, and is succeeded on the slightly higher slopes by very hard conglomerate composed of rounded gravel, which is mixed with boulders composed of angular and subangular fragments. The coarse sediments seem to be derived from the adjacent granitic material. The succession of materials here is like that on the north side of the valley near Souza. On the south side of the valley, in the three places where crossed, the sandstone seems to rest directly on the gneiss, no coarse basal material being in evidence.

Westward from São João the sandstone continues, with slight east dip, for twenty-five kilometers, or to within three kilometers of the head of the drainage basin. At this western limit of the sandstone the surface has quartz-gravel, both rounded and angular fragments, scattered upon it for a few hundred meters; then gneiss appears and continues to Lavras, with the strike swinging from northwest to west and the dip diminishing from nearly vertical southward to about thirty degrees. In some places the gneiss is thinly laminated and is better described as crystalline schist; but in the main it is rather coarsely banded, though crushed, material. At Lavras it strikes S. 80° W., magnetic, or about S. 65° W., true.

Five kilometers north of Lavras the Rio Salgado cuts a small range, the core of which is composed of rock which partakes both of the character of the usual gneiss and also of the muscovite quartzite of Serra de Santa Catharina. It carries less muscovite, but has some garnet, and lenticular veins of quartz and seems to be a quartzose mica-schist, rather than quartzite. The material dips thirty degrees southward and the ridge seems to be monoclinal, as is shown on Plate VIII, fig. 1.

A feature of structural significance seems to be exhibited here in the character of the stream-channel. The gorge is occupied by a pool, partly filled with sand, and the gradient of the stream is determined by a ledge in the channel a few hundred meters downstream. It

appears, that, since the gorge was cut, there has been some depression of the ridge. Soundings made in the gorge in connection with studies for a dam show bedrock to be nine to fourteen meters below the surface of the pool, in which the water is normally two or three meters deep. Similar conditions exist where the Rios Piancó, Aguiar, and Piranhas cross Serra de Santa Catharina, and this range seems also to have undergone subsidence, presumably due to faulting since the streams cut their channels across it.

Crushed gneiss with steep south dip continues southwestward from Lavras. About ten kilometers from this town a band of darker, more schistose rock, three hundred or four hundred meters wide, was crossed, and then a schist or altered shale, with bedding or cleavage planes striking southwest and with vertical dip. This rock continues southwest along Riacho do Meio for a few kilometers, and then seems to be overlaid by red sandstone. This latter is presumably an outlier of a basal portion of the Cretaceous rocks which compose Chapada do Araripe, to the south.[11] Near Ema a band a few meters wide of chloritic (?) schist was seen. It is perhaps a contact metamorphic rock along the border of a zone of dioritic or granitic rock, which extends southward from that point.

Gneiss again appears at Junco, and it forms the Serra de Santa Maria a few kilometers to the south, the dip being steeply southward. Gneiss also forms the hills between the serras of Santa Maria and São Pedro and constitutes the core of the latter range.

Small[12] found that between Iguatú and São Pedro the gneiss has a remarkably constant steep south dip; but that thence northwestward to the vicinity of Tauá and Crateús and thence eastward to Boa Viagem the gneiss is so crushed and crumpled that its structure is not clearly evident, though the dip seems in the main to be steeply to the north or northwest.

About three kilometers southwest of São Pedro, which is at the summit of the range, altered shale appears and continues down the slope to the channel of a small stream ten kilometers from São Pedro. The hills thence to the southwest are in part covered with cherty material for two or three kilometers and then the red sandstone of Chapada do Araripe begins.

[11] The succession of materials composing this highland have been described by Crandall (Publ. No. 4 of the *Inspectoria*, pp. 27–28); and by Small (Publ. No. 25 of the *Inspectoria*, pp. 25–36).

[12] Publ. No. 25 of the *Inspectoria*, p. 40.

From Crato up to the top of the chapada and southwestward across it only the Cretaceous materials are exposed. Its southern border near Novo Exú is formed by a bluff of red sandstone one hundred meters high; but at the base of this bluff granite appears and continues down to the village, four hundred meters below the tableland Thence eastward the granite extends up the chapada slope to Genipapinho, jointing being well developed along the ravine which the road ascends. In the eastern part of Genipapinho red sandstone overlies the granite at an elevation of three hundred and thirty meters above Novo Exú and seventy meters below the top of the chapada. On crossing eastward and descending to Jardim only red sandstone was seen until near the level of the town, where shale appears. In the lower land, twelve kilometers southwest of Jardim, schist at its contact with granite is exposed at a small dam site.

Along the road north from Jardim to Crato and thence west to and beyond Sant' Anna do Cariry only the Cretaceous beds are in evidence. Gneiss reappears twenty-four kilometers northwest of Sant' Anna, with steep southeast dip, and thence forms the hills to the west; but the material is granitic near Assaré. Some variation in texture was observed thence northward, with strike swinging from southwest to west. About eight kilometers southwest of Saboeiro a stream crosses a small range through a gorge, in which a prominent ledge of muscovite quartzite is exposed, dipping nearly vertically to the south, and flanked on each side by schist. Thence to Saboeiro rock, which resembles altered shale, is exposed in several places along the road, and also in the public square at Saboeiro. In every place where observed its dip, nearly vertical, is conformable with that of the schist or gneiss.

Pegmatite dikes are common northwest from Saboeiro, and the usual variations in the texture of the gneiss are exhibited along the valley of Rio Jaguaribe to Arneiroz. A small, isolated range eight to twelve kilometers northwest of Saboeiro seems to be of granite.

Serra de Arneiroz contains a thick ledge of muscovite quartzite which is well exposed on each side of the wide canyon of the Rio Jaguaribe. The ledge dips thirty degrees to the northwest and is flanked on each side by schist (or gneiss?) with conformable dip. Gneiss is thence fairly constantly exposed northward to Tauá, with north to west dip, the strike in this stretch swinging from west through southwest to south. A dark, chloritic rock is crossed by the road for nearly two kilometers,

ten to eight kilometers south of Tauá. This rock seems to be associated with a more feldspathic, pegmatitic material. The strike of the dark ledge may be nearly parallel with the road (north-south), and hence it may form only a narrow zone. A prominent north-south ridge five kilometers southwest of Tauá has a core formed by a vertical ledge of white rock. This may be quartzite, but as seen from the town it appeared to be pegmatite. Several small ledges of pegmatite are present in the lower land near the town.

Between Tauá and Cratheús the gneiss has fairly constant north-south strike. The dip in the main is nearly vertical; but in a few places, notably at thirteen and twenty-five kilometers north of Vertentes, it has low dips. It exhibits the usual phases, from massive granitic to finely laminated material. Near the divide between the basins of the Rios Jaguaribe and Poty the rock is granitic rather than gneissic, but near Vertentes (five kilometers north of the divide), the more typical gneissic phase again is in evidence. For the last six or seven kilometers to Cratheús the gneiss is replaced by pink porphyritic granite. A short distance north of Cratheús the gneiss again appears, and continues, with its usual variations in texture, to the canyon of the Rio Poty. Along this stretch northward from Cratheús the dip of the gneiss flattens, and local crumpling renders the direction of strike indeterminable in some places. Observations in the vicinity of Assis, Aguas Bellas, and Novilho, as plotted on the map (Plate IV), indicate the extent of local variation in the structure.

An escarpment two hundred meters or more in height here forms the east face of the Serra Grande, which is composed of sandstone, which is believed to be of the same Cretaceous series as the sedimentary beds of Chapada do Araripe.[13] The gneiss however is exposed in the channel of the Rio Poty for several kilometers below the head of the canyon. The last exposures observed, before the gneiss disappears beneath the sandstone, exhibit northwest dips. The Cretaceous sandstone thence continues westward, with slight west dip where

[13] Small (Publ. No. 32 of the *Inspectoria*, p. 63 and figs. 15, 16), regards the rocks of Serra Grande as lower Permian or pre-Permian in age, because of certain unconformities he observed between them and Permian beds farther west. Crandall (Manuscript report "*General Notes on Northeastern Brazil*"), and Miguel Arrojado R. Lisboa (*The Permian Geology of Northern Brazil, Am. Jour. Sci.*, May, 1914, fig. 2), consider them to be Cretaceous. Dr. Branner accepts Small's classification on account of the structural relations of the beds, but he recognizes the lack of paleontologic evidence.

any departure from horizontality is recognizable. At Marvão the sandstone seems to dip about ten degrees S. 60° W., but this is probably either local dip or false-bedding, though it is fairly constant for several hundred meters.

About forty kilometers west of Marvão dark-red sandstone appears on the west side of Rio Sucuriú. This rock is different in physical appearance from the Cretaceous material, and the exposure is believed by the writer to mark the eastern limit at this place, of the Permian rocks, which thence extend far to the west.[14]

Northwestern Ceará. Southward from Camocim, on the coast in the northwestern part of the State of Ceará, gneiss first appears at eleven kilometers along the railroad, with a steep south dip; but at Granja the rock strikes about S. 50° W., and dips forty degrees southeastward. Northeast of Granja, toward Parazinho, gneiss is exposed for about twelve kilometers, seemingly with constant southeast dip. Sand and dark-red iron-cemented sandstone of the coastal belt of Tertiary material then cover the surface for a few kilometers; but two or three kilometers southwest of Parazinho low knolls of gneiss rise above the plain, and at the village the gneiss strikes S. 45° W., with dip of eighty degrees to the southeast. Fracture planes traverse the rock at right angles to the strike. One-half kilometer south of the village there is a ledge of quartz; or possibly quartzite, conformable in strike and dip with the gneiss, and this ledge also has fracture planes at right angles to the strike. Southwest of Granja the strike swings to S. 65° W., with vertical dip where noticed, eight kilometers from the town. Thence southward wavy gneiss strikes west with nearly vertical dip. About ten kilometers from Granja ledges of quartzite appear, seemingly interfolded in the gneiss or schist, and thence to a dam site on Rio Itacolomy, twenty-five kilometers from Granja, the quartzite appears at intervals, in several places forming low ridges in the gneissic plain. The strike swings through west to northwest, the dip at the dam site being 45° to the southwest. In a few places the gneiss and quartzite are overlain by thin-bedded red sandstone, one dip of 20° eastward being seen. The material is presumably a remnant of the Cretaceous rocks which compose the Serra Grande.

Near Angico the gneiss dips northwest, but a short distance to the south changes to south dip and continues thus to beyond Riachão.

[14] *The Permian Geology of Northern Brazil*, by Miguel Arrojado R. Lisboa. *Am. Jour. Sci.*, May, 1914, pp. 425–443.

Near Tucunduba, twenty kilometers northeast of Riachão, Small[15] found gneiss and schist dipping northwest on the northern side and southeast on the southern side of a low range there, which accordingly seems to be anticlinal in structure. About thirteen kilometers south of Pitombeiras steep north dip is exhibited, and ten kilometers farther south quartz-gneiss dips north at sixty degrees. A short distance beyond, however, schistose rock dips southeastward, and there is a small area of limestone, which is burned in several kilns. One-half kilometer south of the kilns, or one and one-half kilometers north of Massapê station, dark-red sandstone appears, dipping southeastward at thirty degrees. The sandstone continues along the railroad to one and one-half kilometers south of Massapê, where it lies directly on the gneiss. The gneiss seems to dip steeply northward; the sandstone dips about eight degrees S. 60° E. Prominent cliffs in Serra do Meruoca, to the southwest, seem from a distance to be also composed of sandstone, which presumably belongs to the series which forms Serra Grande.

At Sant' Anna, northeast of Massapê, a wide ledge of white rock, which seemed to the writer to be pegmatite, crosses northward diagonally across the river bed.[16] Thence for three kilometers southeastward the surface is of sandstone, which is well exposed in Serra da Rola, dipping twenty-five degrees northward. Small[17] found that this sandstone extends several kilometers to the north, and forms a gentle syncline north of Sant' Anna. He considers the area to be an outlier of the Cretaceous sandstone of Serra Grande. He records[18] dips of 70°–90°, N. 20° E. (mag.?) in gneiss near Marco, fifty kilometers north of Sant' Anna, and near Itapipoca, seventy kilometers east of Sant' Anna, he found the gneiss dipping southeastward, close to the granite of Serra de Uruburetama. In a hill near Serrote, forty kilometers farther east, he noted vertical quartzite striking south.

From Sant' Anna southeastward to São Pedro de Timbauba the gneiss contains several areas with much quartz, seemingly as quartz veins and pegmatite dikes. Along this distance the strike of the gneiss swings from south-southwest through southwest to west, the dip being near vertical southward.

[15] Publ. No. 32, of the *Inspectoria*, p. 49.

[16] Small (Publ. No. 32 of the *Inspectoria*, p. 50), considers this ledge to be probably of haplite.

[17] Publ. No. 32 of the *Inspectoria*, pp. 50–51.

[18] Publ. No. 32 of the *Inspectoria*, pp. 45–47.

Southward from Massapê along the railroad the gneiss is much veined with quartz, and disintegrated; and no good exposures showing the strike were seen until twelve kilometers south of Cariré. The strike there seems to be westward, with steep north dip; but eight kilometers farther south the dip seems to swing to the northeast, and at Santa Cruz a steep southeast dip was noted. For a few kilometers to the north and south of Ipú the railroad crosses sandstone at the base of Serra Grande, which rises abruptly from the gneissic plain, as shown in Plate VIII, fig. 2. Gneiss reappears along the railroad three kilometers south of Ipú, though too deeply disintegrated for its structure to be easily determinable. Near Nova Russas, and thence southward to Novilho (the railroad terminus in 1911), the gneiss seems to have constant southwest strike, with steep northwest dip.

From Fortaleza to Iguatú. The observations of strike and dip along the railway between Fortaleza and Iguatú were taken, and checked, from the rear of the train during four trips over the line. Although some of these observations of direction may be in error, it is believed that they show correctly the general character of the folding along this strip of country.

Southward from Fortaleza gneiss was first seen, outcropping from beneath the coastal belt of sedimentary materials, near Monguba. It there strikes south, with nearly vertical dip, and is cut by small pegmatite dikes. Thence southward the strikes gradually swing to about S. 60° W., near Acarape with steep northwest dip. At Itapahy, crystalline limestone and quartz associated with the gneiss, strike southwestward with nearly vertical dip. From Itapahy to Baturité the rock seems to be all gneissic, but the strike seems to vary considerably, swinging from southwest to northwest and back to southwest, with dips that indicate much folding into steep anticlines and synclines. The character of the rock also changes considerably, being crushed gneissic to about Canafistula, where it more resembles a crushed granite. At Aracoyaba it might be classed as a granitic gneiss. Thence to beyond Baturité there is deep red (decomposed granite?) soil. Between Baturité and Junco the strike seems to be fairly constant, westward, but reversals in dip show considerable folding. For some distance south of Baturité gray soil (gneissic?) covers the surface, but near Riachão fresh gneiss with wide banding is exposed. Thence southward it is again disintegrated on the surface, and three kilometers south of Castro the rock is more granitic. Fresh

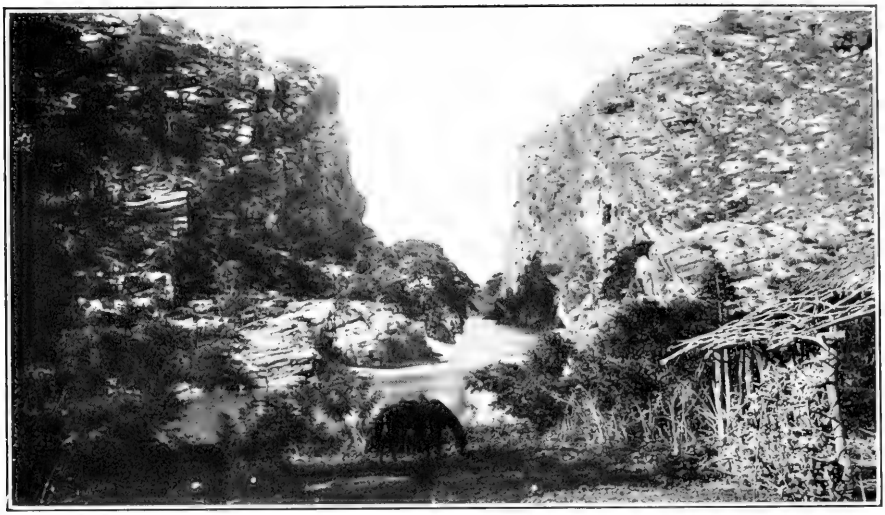


FIG. 1. Mica-schist at the dam site on Rio Salgado near Lavras, Ceará.

FIG. 2. Cretaceous sandstone of Serra Grande near Ipú, Ceará, overlying the plain of crystalline rocks.

gneiss with nearly horizontal foliation planes is in evidence two kilometers north of Cangaty; then follows a zone with much pegmatite. At Cangaty station crushed gneiss carrying narrow pegmatite dikes dips steeply to the south and there seems to be a sharp syncline near this place. Thence southward to Junco pegmatite is less in evidence. Between Junco and Quixadá there is an area with prominent granite hills, fluted and pitted, the highest of which rises 225 meters above the plain (Plate IX, fig. 1). The character of the fluting and pitting in these hills, and the way in which it has been accomplished has been described by Dr. J. C. Branner.[19] Even in this granitic area there is some evidence of the northeast-southwest strike which is exhibited in the gneiss to the north and to the south; and it seemed to the writer that the fluting and pitting was to some extent determined by this structure, the fluting being chiefly on cliffs facing northwest or southeast (perpendicular to the strike), and the pitting being best developed on the northeast and southwest portions of the hills.

Serra do Estevão, west of Quixadá, rises three hundred and fifty meters above the plain. Gneiss forms the main body of this serra, and dips steeply to the southeast. South of Quixadá gneiss reappears beyond the granitic area, with prevailing south-southwest strike and steep easterly dip; but the higher land near Floriano Peixoto is again granite, which is possibly the core of an anticlinal fold. Thence the railroad descends across a plain of gneiss which exhibits constant southward strike, to Quixeramobim, where the strike is S. 60° to 45° W., magnetic, or about S. 45° to 30° W., true, with vertical dip. About two kilometers west of Quixeramobim the gneiss strikes S. 10° W., true, with dip of 70° eastward. To the east, throughout most of the distance between Quixeramobim and Morada Nova, Small[20] found gneiss and schist to have fairly constant steep east or southeast dips. Southward from Quixeramobim the railroad ascends to an area of granitic domes and perennial ponds, the latter being unusual in this arid region; and the track winds between the hills and ponds to Prudente de Moraes. About thirteen kilometers north of this station the granite contains large feldspars. South of the station the

[19] *The Fluting and Pitting of Granites in the Tropics.* By J. C. Branner. The Papers of the Stanford Expedition to Brazil in 1911, Vol. I, 3–30. Stanford University, 1914.

[20] Publ. No. 32 of the *Inspectoria*, p. 31.

rock near the railroad is a coarsely granular gneiss, but there are low granitic domes a short distance away. At Senador Pompeu the gneiss strikes S. 10° W., with vertical dip, but there seems to be considerable variation in the direction of strike for several kilometers north of this city. Southward also, the gneiss seems to be somewhat crumpled, and to be sharply folded; but near Lages the strike becomes more uniformly to the southwest, and thence to Iguatú swings gradually to the west, but with some sharp folding.

The rock changes in character, as well as in strike and dip, southward from Senador Pompeu. At this city it is much crushed, with quartz, mica, and hornblende segregations. Southward the rock is fresher and less crushed, with massive granitic material halfway to Giráo; but at this station decomposed gneiss is again prominent and continues up across a low divide, down to Miguel Calmon, and southward to the valley lands near Iguatú. The valley near Iguatú is in part occupied by red sandstone, which is considered by Small[21] to be a shallow synclinal remnant of the Cretaceous series. Near the base of a low gneiss hill fifteen kilometers southwest of Iguatú the sandstone dips gently northeast. The gneiss dips steeply to the north. Thence westward to São Matheús the gneiss has a constant strike a little south of west; and schist five kilometers east of São Matheus exhibits the same strike, with vertical dip.

West of Natal. On the railroad which runs westward, inland from Natal, the western margin of the coastal sedimentary rocks is reached about halfway between Ceará-Mirím and Taipú. This railroad was not traversed by the writer beyond the former station, but the following note on the character of the crystalline rocks exposed along this railroad is given by Jenkins:[22]

"In all the railway cuts it was noticed that dikes of granites and pegmatites cut through micaceous schists. These dikes vary in width from one to thirty meters, sometimes following the plane of schistosity and sometimes cutting across it. Often one dike intersects another. These dikes and schists do not show in the topography; all are eroded and decomposed to the same surface level."

From Natal to Recife. Along the railroad southward from Natal the

[21] Publ. No. 25 of the *Inspectoria*, p. 57, Pl. I.

[22] *Geology of the Region about Natal, Rio Grande do Norte, Brazil*, by Olaf Pitt Jenkins. *Proc. Am. Phil. Soc.*, Sept.–Oct., 1913, p. 12; *Stanford Expedition to Brazil in 1911*, Vol. I, pp. 55–107.

inland edge of the coastal belt of sedimentary rocks is reached near Villa Nova, where gneiss is first exposed striking about S. 15° W., with vertical dip. In the higher land between Villa Nova and Nova Cruz granite is exposed, but at the latter place and thence southward to Independencia gneiss is fairly continuously exposed, with constant south-southwest strike and nearly vertical dip. At Independencia the schists dip 45° to the southeast. East of the railway, toward Mamanguape, the strike changes to northwest, with steep dip to the northeast. Near Mamanguape there is an intrusion of granite, which is in evidence eastward to the eastern part of the city, where it is overlain by the coastal beds. Southward from Independencia the strike seems to swing through south to nearly east, with some crumpling and folding between Pau Ferro and Araça. Near Araça the railroad climbs from the gneissic lower lands to a tableland covered with sedimentary materials, and crosses this to a short distance south of Sapé, where it descends again to the gneissic lowlands. At Entroncamento the gneiss strikes west, with dip of 70° to the south. Thence southwestward, there seems to be some crumpling between Coitezeiras and Pilar, but near Itabayanna the gneiss again strikes west, with steep south dip.

About five kilometers west of Itabayanna, on the railroad to Campina Grande, there are dark bands, seemingly dikes, ten to forty centimeters wide, which traverse the crumbling, disintegrated gneiss, and along the grade up to Campina Grande there is much pegmatite; but satisfactory observations on the structure along this line were not obtained.

Southward from Itabayanna, up grade to the summit near Rosa e Silva, the gneiss dips fairly constantly southwestward. Thence down to Nazareth the strike seems to vary much, as observed from the train, though some of the variations indicated on the map may be errors in observation. Near Nazareth granitic gneiss, somewhat disintegrated, dips 20° to 30° east to northeast. At and about Floresta the hills are capped by sedimentary beds. Thence to Recife the strike of the crystalline rocks seems to become more uniformly westward.

Salient Features of the Bedrock Structure in the North. It is fully realized that observations of strike and dip along a few widely separated lines in a region of intense folding may be susceptible of various interpretations, and that conclusions drawn from such scanty evidence

may not be warranted. It seems to the writer, however, that a few salient features are indicated by the observations of structure in the gneiss, schist, and quartzite, in the area shown on the northern sheet of the accompanying map (Plate IV). Sharp anticlines and synclines seem to be shown by the reversals in dip in a number of places. In a few places monoclinal structures, notably at the Lavras dam site, presumably are the result of faulting. In addition to these minor structures, a major feature seems to be indicated by the change in the mean direction of the strike. From a general east-west course in the zone from near Soledade westward to Assaré, it swings to a northeast-southwest direction in the region north of this zone and also between Assaré and Arneiroz, and to a north-south direction in the zone thence northward to Cratheús. The direction of strike along the railway between Iguatú and Quixadá, although varying considerably, seems as a whole to conform to this general plan. The direction of trend of the planes of foliation seems to be such as might be produced by compressive forces acting from the south and the west.

This hypothesis is advanced with due appreciation of the fact that it is based on incomplete data as to structure throughout the area supposed to be involved in such compression; but the topographic evidence, so far as the mountain ranges have been mapped, seems to corroborate the evidence furnished by observations of the strike. Attention is called to the east-west trend of the range composed of the serras of Vital, Santa Catharina, and Melado; to the northeast-southwest trend of Serra da Barriguda and associated ranges, and Serra do Camara and its northward extensions, and to the north-south trend of Serra dos Orós and the range or series of hills extending north from it. Farther west, topographic evidence of the same major structure seems also to be indicated by the nearly east-west trend of Serra de São Pedro, by the northeast-southwest trend of Serra dos Bastiões and Serra de Arneiroz, and by the more nearly north-south trend of Serra do Flamengo and Serra do Maia. Somewhat similar general structure for this region was implied by Crandall,[23] who observed that the granitic ranges nearly all trend northeast-southwest, the only notable exception being Serra do Pereiro, which trends more nearly north-south.

So far as was observed, the foliation planes do not tend to wrap themselves around the granitic masses. In some areas comparatively

[23] Publ. No. 4 of the *Inspectoria*, p. 27.

rapid variation in the direction of strike of the foliation planes indicates contortion, notably in the mountainous area between Quixeramobim and Cratheús, where the ranges also have various trends. In general, however, both the strike and the dip seemed to the writer to be fairly constant over considerable distances, and it seemed that it would be easily feasible to work out the major foldings in the basement series. Most of the region is covered with a dense growth of small, thorny trees and tall cactus, and in very few places would it be feasible to follow geologic contacts; but pack-trails which have been cut through this growth connect all the numerous small settlements, and by traversing them a sufficiently good network of meander lines would probably be obtained to permit the mapping of the geology with fair accuracy.

Structure South and West of Recife. Satisfactory notes on the bedrock structure along the railway from Recife to Maceió were not obtained by the writer, and the line west from Recife was not traversed. Observations along these lines have been published by Dr. Branner.[24]

The structure exhibited along the railway line, running westward from Recife shows nearly uniform east-west strike, with steep dips to north or to south, between Recife and Antonio Olyntho. East-west strike is also shown along the railroad southward as far as Gamelleira. From there to Marayal the strike is to the southwest. Westward from Marayal there seems to be an area of much crumpling.

Structure in the Southern Area. A wide area of sedimentary rocks extends northward inland from the city of Bahia, but along the valley of the Rio Itapicurú granite is exposed. Along the railway it first appears five and a half kilometers northward from Aporá. Near the river gneissic phases exhibit steep south dips. In the cut a short distance north of the river a vertical band of serpentine is exposed, and a little farther north the gray granite is traversed by nearly vertical stringers of quartz and pegmatite. In one place rounded boulders, produced by concentric weathering, are in evidence. The plateau in the vicinity of Barracão is capped by sedimentary materials, but three or four kilometers beyond the town granitic gneiss appears in the descent to Rio Real. Half-way between the town and the

[24] *Geology of the Northeast Coast of Brazil, Bull. Geol. Soc. Amer.*, Vol. XIII, pp. 41–98; *Proc. Wash. Acad. Sci.*, Vol. II, pp. 195–201, and *Am. Jour. Sci.*, Feb., 1902.

river the strike seems to be westward, with nearly vertical north dip, but at the river the rock dips steeply to the northwest.

Northwestward from Alagoinhas gneiss is first seen near Agua Fria, which marks the western limit of the coastal sediments, where crossed by the railway, but the first good exposure, showing structure which was noted, is near Lamarão, where the dip seems to be gently westward, and continues thus nearly to Serrinha, where the dip is southward. Between this place and Salgada there seems to be considerable variation in the direction of strike. This may be in part due to error in the observation of low dips and to the wavy character of the foilation planes; for, as the dip becomes steeper, the strike seems to become more uniform northwestward. North of the railway along this stretch there is a considerable area of porphyritic granite. Where it is crossed by the main road between Serrinha and Aracy the granite is ten kilometers wide, extending from one kilometer south of Pedra to within nine kilometers of Aracy. On the north and south it is bordered by zones of crushed gneiss, which contains much quartz. Similar crushed material, which carries much quartz and feldspar, and is traversed by dark bands rich in hornblende and black mica, outcrops one kilometer southwest and south of Aracy and exhibits steep west dip. About five kilometers west of Aracy less crushed phases of this material are traversed in all directions by narrow pegmatite dikes which consist of feldspar and quartz, with very little mica, hornblende, or tourmaline.

At Santa Luzia the gneiss dips steeply to the southwest. Near this town there are several prominent hills of gray granite, and thence for several kilometers along the railroad the rock is all granitic. Halfway to Queimadas it becomes gneissic again, but with dip to the northeast, instead of to the southwest, as at Santa Luzia. Unless there is other folding these dips indicate that the granite is in a synclinal fold. At Queimadas the gneiss dips west at an angle of twenty degrees, but thence northwestward the dip steepens as Serra da Itiuba is approached. The south end of this serra is crossed by the railroad, along which the strike of the gneiss flanking the range on each side is north-south, conformable with the trend of the latter. This structure continues northwestward along the railroad with little interruption, to the vicinity of Jaguarary, where granite is exposed for a few kilometers. Near Itumirim a small exposure of gneiss shows the usual north-south strike, with vertical dip. The region between

Angico and Carnahyba is largely covered with a thin layer of desert limestone, but at Angico and at Jurema small exposures of gneiss show general northward strike and nearly vertical dip. At Carnahyba a poor exposure of the gneiss seems to have its foliation planes striking west. Between Carnahyba and Joazeiro granite appears. On a small island in the river near Joazeiro, and on the opposite shore, a dark crystalline rock of granitic texture is well exposed.

From Bom Fim and Queimadas excursions were made in the basin of Rio Itapicurú, and the strike of the gneiss wherever observed was found to be conformable with the north-south trend of the serras of Itiuba and Jacobina.

Serra da Itiuba is a granitic range, rising two hundred to three hundred meters above the surrounding country. Much of the material composing it exhibits gneissic banding, but the core of the range seems to be of massive granite. Where the main drainage divide was crossed two kilometers west of Caldeirão de Vaca it is a red granite. East of the range there is also some granite, the most prominent exposure being at Pedra Vermelha, where a bare, rounded mass, one hundred by three hundred and fifty meters, trending N. 15° E., rises twenty-five meters above the plain. At its west base there is perennial water in a small, undrained area, deeply filled with soil in which fossil bones are found. Among specimens obtained by the writer were several teeth, one of which was pronounced by Dr. W. J. Holland, of the Carnegie Museum, Pittsburgh, to be the tooth of a horse, another the fragment of a tooth of a mastodon, and another to be a molar of *Toxodon Burmeisteri*, which had not been reported from so far north in Brazil.[25] Other specimens sent to Dr. Holland have been examined by him, and as an appendix to this paper he gives a list of this material. (Cf. p. 224.)

The presence of fossil bones in a similar marsh at Lagoa da Lagea, three hundred kilometers to the northeast, has been noted by Dr. Branner.[26]

One feature of the granitic gneiss in the vicinity of Caldeirão Grande, southwest of Serra da Itiuba, is the presence of holes, like

[25] W. J. Holland, *To the River Plate and Back*, G. P. Putnam's Sons, New York, 1913, p. 210.

[26] *On the Occurrence of Fossil Remains of Mammals in the Interior of the States of Pernambuco and Alagôas, Brazil*, by John C. Branner, *Am. Jour. Sci.*, Feb., 1902, pp. 133–137.

that shown on Plate IX, fig. 2, which form convenient storage tanks for water. These can not be considered as potholes produced by stream action, because they are not suggestively situated with respect to drainage channels. The holes are considered by Dr. Branner to have been produced by the action of organic acids in disintegrating the less resistant spots in the rock, and the removal of the material by the overflow of muddy waters in the same way that the basins on granite hills near Quixadá in Ceará may be explained. Some of these basins have also been cleaned out by man to serve as storage reservoirs for water.[27]

The Jacobina range is of quartzite and schist, flanked by gneiss and granite. So far as is known to the writer the relation of the quartzite and other altered sedimentary rocks which have been named the Minas Series, to the Ceará series of similar materials, farther north, has not been determined. The structure of the range has been discussed by Dr. Branner,[28] who regards it as being composed of blocks of quartzite. Subsidiary ledges of quartzite wherever observed have strike conformable with that of the main range. To the northwest there are prominent though minor quartzite ridges between Itumirim and Angico. To the east such ridges were noted by the writer at Palmerinhas, and at Morro da Maravilha. Approximately as far east of Serra da Itiuba as Serra de Jacobina is west of that range, there is a range of hills culminating at the south in a hill at Monte Santo which rises three hundred meters above the plain. This hill has a core of quartzite, standing nearly vertical, with strike N. 10° E., magnetic, or about N. 5° W., true.

A range of serras farther east, extending from south of Cumbé nearly to Canudos, and composed in part of quartzite, have been described by Soper.[29] Earlier discussions of the structure of Serra Itabaiana have been published by Dr. Branner.[30]

West of the Bay of Bahia, along the railway which runs north from Cachoeira to Feira de Sant' Anna, gneiss and granite are exposed, but

[27] *Geologia Elementar* por J. C. Branner, 2d ed., pp. 50–51. Rio, 1915.

[28] *The Geology and Topography of the Serra de Jacobina, State of Bahia, Brazil,* by John C. Branner, *Am. Jour. Sci.*, Dec., 1910, pp. 385–392.

[29] Publ. No. 34 of the *Inspectoria*, pp. 19–25.

[30] *The Cretaceous and Tertiary Geology of the Sergipe-Alagôas basin of Brazil, Trans. Am. Phil. Soc.*, Vol. XVI, 1889, pp. 379–382.

The Geography of Northeastern Bahia, Brazil, The Geographical Journal, Aug.–Sept., 1911, pp. 145–148.

FIG. 1. Fluted and pitted granite hills near Quixadá, Ceará.

FIG. 2. Basin in granitic gneiss traversed by dikes, at Caldeirão Grande, Bahia.

no good observations of the strike were obtained. At Bananeiras, fifteen kilometers northwest of Cachoeira, gneiss is well exposed in the channel of the Rio Paraguassú, dipping 70 degrees to the southwest. Westward from Cachoeira, gneiss is exposed along the railroad shortly after leaving São Felix. The strike is northward, with steep west dip, and continues thus nearly to Pombal, where a reversal in the dip indicates a synclinal fold. Thence to Candial there is apparently some crumpling, as the strike, as observed from the train, seems to change its direction, as indicated on the map, Plate V, with dips lower than usual. Westward from Candial the strike seems to be constantly northward, with steep dip to the east. At Tapera a small vein of serpentine was observed in the country-rock, which in the vicinity is granitic rather than gneissic. On the south side of the railroad between Tapera and Tanquinho there is a group of granitic hills which are carved into cavernous forms by the weather. Along the railroad, however, the rock is gneissic; and beyond the group of hills, unless the observations are in error, the strike swings to northwest. Between Lapa and Sitio Novo the strike returns to a north-south course. Westward from Sitio Novo, to and probably beyond Caixão, the rock is granitic rather than gneissic.

The most salient feature in the structure of the basement rocks in this southern area, west and northwest of Bahia, seems to be the prevailing northward strike, conformable with the trend of the principal mountain ranges. Some crumpling seems to have taken place in restricted areas, but in general the foliation planes seem to hold constant strike over long distances.

THE CEARÁ SERIES.

Notes concerning the character and distribution of the rocks of the Ceará Series have been published by Crandall,[31] Small,[32] and Soper,[33] in reports issued by the Brazilian Government. Crandall, who named the series, and has examined these ancient sedimentary rocks more closely than others, says that the series seems to consist chiefly of schists, which in the southern part of the State of Parahyba possibly attain a thickness of a thousand meters. In places a hard, quartzitic

[31] Publ. No. 4 of the *Inspectoria*, pp. 22–25.

[32] Publ. No. 25 of the *Inspectoria*, p. 38.

[33] Publ. No. 26 of the *Inspectoria*, p. 19, also *Proc. Am. Phil. Soc.*, Vol. LV, No. 1, 1916, p. 7.

sandstone seems to overlie the schists, its thickness, where observed, being not over one hundred meters. In a number of places there are masses of crystalline limestone. It is not evident whether or not these masses represent a regular bed, but it seems more probable that the limestone is present as lenses, at about the same geologic horizon in the series. The rocks are greatly jointed, but do not exhibit much folding or crushing. Where the schists exhibit shearing they have been hardened, so as to form resistant layers which rise above the general level. Many irregular dikes of pegmatite and other acid rocks have been injected into the schists.

To the quartzite, crystalline limestone, and schists should probably be added shales, good exposures of which were seen by Small[34] in the extreme southern part of Ceará.

Small says of the schists that it is in most places difficult to distinguish between those of the Ceará Series and the crystalline schists of the basement complex; but that the former seem to be softer and more argillaceous and to disintegrate more readily to soil. In some places in the Ceará Series mica-schists and rocks rich in manganese and iron predominate, and amphibolite-schists are also common.

Soper says:[35] "The Ceará Series, where it is distinguishable, seems to be composed of acid rocks, usually of a light color. They contain more or less kaolin and clay and in some cases have a peculiar earthy appearance. On weathering off they do not weather into rounded boulders with smooth surfaces, but outcrop in jagged exposures, and the boulders, large and small, have sharp edges—not rounded ones. The Ceará Series usually presents a schistose appearance and in places according to Mr. Crandall, may contain lenses of hard, vitrified sandstone. In other places there are masses of limestone completely isolated in areas of schist. However, there does not seem to be any systematic separation of this series from the other rocks and it is often, if not usually, impossible to make any distinction at all."

Wherever the Ceará Series was definitely recognized by the writer, by the presence of quartzite or of crystalline limestone, the general characteristics of the associated schists, as given by Crandall, Small, and Soper, were noticed. The impression obtained by the writer was,

[34] Publ. No. 25 of the *Inspectoria*, pp. 49–41, and Photograph No. 21.

[35] *The Geology of Parahyba and Rio Grande do Norte, Brazil*, by Ralph H. Soper, *Proc. Am. Phil. Soc.*, Vol. LV, No. 1, 1916, p. 7.

however, that although the series has wide distribution, it occupies much more restricted areas than has been heretofore assumed, and that the greater part of the schist belongs to the crystalline series. The reasons for believing this are: The gneissic or crystalline schistose appearance of most of the material observed; the relative scarcity of deposits of quartzite and crystalline limestone in the series; and the difficulty of accounting for wide areas of schist of the series by repetition due to close folding or to faulting, because the dip of the foliation planes seems to have constant direction at angles of 70° to 90° for distances of many kilometers.

The following notes on observed occurrences of the Ceará Series are presented for such information as they may furnish on the areal distribution of these ancient sedimentary rocks.

On the journey westward from Campina Grande quartzite was first definitely observed four kilometers north of Periquitos; but to the south, toward Viração, a thick white ledge probably is also composed of quartzite, and northeast of Batalhão schists, which weather into gravestone-like projections, may belong to the series. It seems as if a considerable belt between Batalhão and Parellas may be composed of the quartzitic and schistose members of the series.

East of Caicó crystalline limestone is exposed for perhaps two kilometers in the vicinity of Barra do Mainoso. In the vicinity of Caicó and for at least five kilometers northward there are wide white ledges, which were taken to be quartz-veins. They may possibly be quartz-lenses in schists of the Ceará Series.

About twenty-five kilometers southeast of Apody a bed of schist and crystalline limestone a few meters thick flanks a low ridge, which seems to be largely composed of cherty material. Crystalline limestone is also exposed on the opposite, or northern, side of the ridge, which may constitute a narrow anticlinal zone of materials of the Ceará Series.

Serra Araré, near the mouth of Rio Jaguaribe, is composed in part of red quartz-schist or quartzite; and minor ledges of white quartzite (or veins of quartz) traverse the lowland near the base of the small mountain.

In the remarkably straight east-west range formed by the serras Vital, Santa Catharina, and Melado, quartzite and mica-schist are well exposed where the range is crossed by the Rios Piancó, Aguiar, and Piranhas. To the writer the range seemed to be perhaps a narrow

anticlinal zone of the ancient sedimentary rocks, flanked on each side by gneiss or schist.

Near Lavras there is a small serra, cut through by the Rio Salgado. The rock exposed in the river gorge partakes both of the character of gneiss and crystalline schist, carrying less muscovite than the quartzite near Curema, but it contains garnets. It seems to be a small, isolated mass of the quartzitic material of the Ceará Series.

Between Lavras and Crato there are a few exposures of altered shale, which, because of their nearly vertical dips, evidently do not belong with nearby basal materials of the Cretaceous series. They may be of the same horizon as shales found by Small farther south along Riacho dos Porcos east of Jardim, which he classed with the Ceará Series.[36]

About eight kilometers south of Saboeiro muscovite-quartzite is prominently exposed in a small ridge where cut by the gorge of a stream. The quartzite is flanked on each side by thinly laminated schist, and half-way to Saboeiro a dark material, resembling an altered shale, is exposed for a few meters along the road. Other small exposures of this rock were seen in and near Saboeiro. About fourteen kilometers northwest of this town a small patch of crystalline limestone beside the road was noted by the writer's associate, Dr. Manoel Arrojado Lisboa.

Near Arneiroz the Rio Jaguaribe crosses a small serra, in which there is a wide ledge of white quartzite, flanked by gneiss or schist. At Poço dos Paús, which is half-way between the quartzite ledges of Arneiroz and Lavras, and east-northeast along the trend of the ledge near Saboeiro, there are soft decomposed schists, with lenses or beds of quartzite having a maximum thickness of about four meters.[37] These may be of the Ceará Series, though there seemed to be only a small area of such material. Northwest of Arneiroz, half-way to Tauá, altered shale was again seen for a few meters. Near Tauá there is a prominent hill, which has as a core a vertical ledge of white rock, which appears from a distance to be quartzite, though close examination may show it to be a thick pegmatite dike.

About eight kilometers southeast of Cratheús there is a small area of crystalline limestone, locally burned for lime, and also small ledges

[36] Publ. No. 25 of the *Inspectoria*, p. 40.

[37] Small presents a detailed geologic map of this locality in Publ. No. 25 of the *Inspectoria*, Pl. V.

at kilns at the eastern base of Serra do Estevão, near Quixadá. The limestone proves the presence of at least remnants of the Ceará Series in these two localities. Limestone is also burned near Massapê, but the presence in the vicinity of sandstone, which is probably of Cretaceous age, indicates that the limestone may also belong to this later period. Neither outcrops nor specimens of the limestone were seen by the writer.

In the northwestern corner of Ceará there is much quartzite in the lower slopes and outliers of the Serra Grande, and the rock is well exposed in the lower land as far northeast as a gorge on Rio Itacolomy, twenty-five kilometers south of Granja. Minor ledges of quartzite or veins of quartz are found nearer to Granja, and at Parazinho, northeast of Granja, there are ledges of white rock, taken by the writer to be veins of quartz, which may be lenticular masses in schists of the Ceará Series.

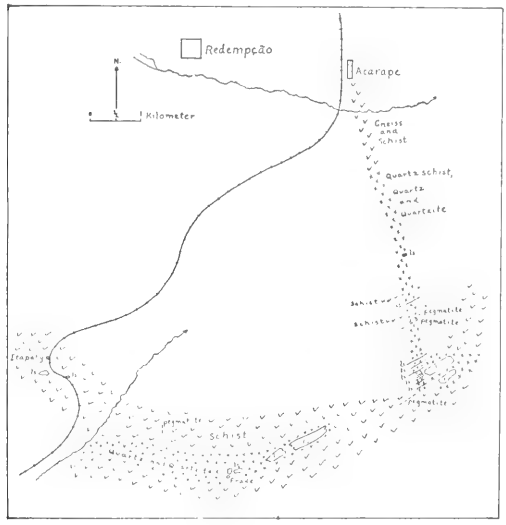


FIG. 2. Sketch map, showing the geology in the vicinity of the crystalline limestone masses near Acarape, Ceará.

Probably the most striking exposures of the Ceará Series in the State from which it is named are formed by crags of limestone near Acarape, about seventy kilometers south of Fortaleza. The approximate distribution of the limestone, and its association with quartz,

schist, and pegmatite, are shown in the sketch map (text-figure 2). Much of the siliceous material seems to be in the form of veins and lenses of quartz, but the wider areas may be of quartzite. In the main the limestone outcrops as a series of craggy masses (Cf. Plate X, fig. 1), along a zone about one-half kilometer wide, which extends in a nearly straight line S. 60° W., magnetic, for a distance of five kilometers. The northeasternmost outcrop observed is on a steep hillside of white quartz (or quartzite), and the southwestern exposure culminates in a prominent pillar called 'Frade' = The Monk (Cf. Plate X, fig. 2), which is at the northwestern base of the steep quartz or quartzite slopes. In the area lying north of the main zone small outcrops of limestone were seen beside the railroad near Itapahy station, a few kilometers northwest of the 'Frade,' and at the margin of a pond between the northeastern end of the zone and Acarape. The limestone masses seem to be bordered on each side by quartz. Quartz (or quartzite) slopes rise directly south and east of the pillar 'Frade,' and a boulder near the pillar exhibits a contact zone about one meter wide, of alternating bands of quartz and limestone, as shown in Text-fig. 3*a*. In the railway cut one-half kilometer south-

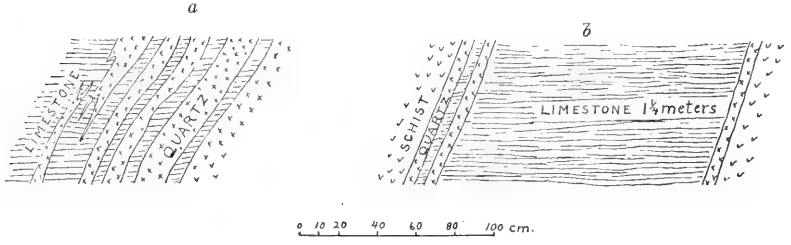


FIG. 3. *a*. Section showing alternation of quartz and limestone in a boulder at 'Frade' near Acarape, Ceará.

b. Section showing alternation of quartz and limestone in railway cut, one-half kilometer S. E. of Itapahy Station near Acarape, Ceará.

east of Itapahy bands of limestone and quartz are exposed as shown in Text-fig. 3*b*. The limestone is not exposed on the opposite (western) side of the railroad cut, which is of gneiss, with a smooth surface like that of a movement plane. The pegmatite dikes in the northeastern portion of the quartz and limestone area seem to strike in the same direction as the limestone; but in the area of schist between "Frade" and Itapahy a small pegmatite dike trends southward until it meets the quartz and then disappears.

The foregoing notes on places where quartzite or crystalline limestone were seen, indicate that these members of the Ceará Series are widely distributed, though, where present, they cover only small areas. Whether the schists, which probably constitute the greater part of the series, are also limited to relatively small patches or belts, or whether they form the bed-rock throughout a large part of the region, is a question which involves their definite recognition and separation from the similar materials of the crystalline series.

THE GRANITES.

In his reconnaissance in the northern part of the region under consideration Crandall recognized that the granites are intrusive in the gneiss and schists, and he observed that the principal granitic masses trend northeast-southwest.[38] Small[39] has called attention to the seeming gradation of gneiss into granite on the one hand and crystalline schist on the other. He also notes that granite seems to be found chiefly in the crystalline schists, rarely in the argillaceous schists (of the Ceará Series).[40] The only place in which he observed granite intruded into the series seems to have been along the Riacho dos Porcos, in the extreme southern part of Ceará.[41]

Most of the bare, isolated hills, like those shown on Plate VI, fig. 2 and Plate VII, fig. 2, are of granite, chiefly of gray, medium-grained material; but in a few places pink or red granite has been observed, and coarsely porphyritic phases have been noted. Granite to the southeast, also northwest of Cratheús, may be described as a pink porphyry. Along a narrow zone westward from Campos Salles to Jaicós and thence southward to Simões, Small found pinkish granite.[42] Dr. Branner noticed red "Scottish granite" along the railroad west of Caruarú (136 km. west of Recife).[43] Rock which contains feldspars fully three centimeters in length is crossed by the railroad south of Prudente de Moraes (258 km. south of Fortaleza), and similar coarsely porphyritic rock is present at the southern base of Serra da Barriguda near Jericó.

[38] Publ. No. 4 of the *Inspectoria*, pp. 23 and 26.
[39] Publ. No. 25 of the *Inspectoria*, p. 38.
[40] Publ. No. 25 of the *Inspectoria*, p. 41.
[41] Idem, *Loc. cit.*, p. 41.
[42] Publ. No. 32 of the *Inspectoria*, p. 73.
[43] *Geology of the Northeast Coast of Brazil*, p. 81.

RESUMÉ OF MAJOR FEATURES.

In structure, the Brazilian Complex is in nearly all places closely folded, and in restricted areas contorted; and probably it has also been extensively faulted. On the whole the dip and strike of the foliation planes of its gneisses and schists are fairly constant over considerable areas, and it seems probable that the major folds can be worked out with a fair degree of accuracy, without excessively tedious study on the field.

The distribution of the Ceará Series and the areas occupied by it are at present very imperfectly known; chiefly because of the similarity of the schists of this series with the crystalline schists. Detailed study will, however, probably develop criteria by which distinction can be made in the field.

The granites, have not been studied sufficiently to warrant statements as to whether or not they represent more than one period of intrusion, nor as to whether they are intrusive in both the Brazilian Complex and the Ceará Series, or only in the former. The difficulties involved in the elucidation of this problem are probably very similar to those encountered in studies of similar complex formations in the Sierra Nevada of California and in New England.

MINOR FEATURES.

In addition to the problems presented by the structure in the Brazilian Complex, by the distribution of the Ceará Series, and by the nature of the granitic intrusions, which seem to the writer to be major features of the geology of Northeastern Brazil, there are three minor subjects which especially attracted his attention. These are the presence of quartz-gravels, widely distributed over the bedrock surface, the comparatively rare occurrence of basic igneous rocks, and the scarcity of springs, especially springs of thermal or of notably mineralized water.

Quartz-Gravels. Throughout the region discussed in this paper there are narrow belts and wider, more scattered, deposits of gravel, composed almost entirely of subangular to well-rounded fragments of quartz. In many places the source of the material is apparent in neighboring beds of quartzite, veins of quartz, or dikes of pegmatite, the material evidently being residual from the disintegration of ledges of these rocks. In other places, however, no such connection is clear,

FIG. 1. Limestone crags near Acarape, Ceará.

FIG. 2. Limestone pillar, 'Frade,' near Acarape, Ceará.

and the position and character of the gravels point toward the action of water.

Between Campina Grande and Soledade much angular to subangular quartz-gravel is scattered over the surface and is derived from numerous quartz-veins in the gneiss.[44]

North of Periquitos the surface is covered with much angular gravel, which is probably derived from pegmatite dikes, which are abundant in the locality.

For two or three kilometers south and west of Jardim de Seridó unassorted, but fairly well-rounded, quartz-gravel covers the surface. In places it is mixed with angular material, which looks as if it were disintegrated in place. The rounded material seems to form a thin layer over lands which are well above present stream-channels. Northeast of Jardim de Seridó angular quartz-fragments up to ten centimers in dimensions are scattered over the surface; and in several places, notably at six, ten, eleven and eighteen kilometers from the town, belts of unassorted, but rounded, gravel form thin layers over the gneiss. The northernmost belt, fifty meters wide where crossed by the road to Acary, is on land forming a plateau. Westward from Acary there is a thin layer of angular white quartz fragments over much of the surface. About sixteen kilometers west-southwest of Acary the road passes for nearly half a kilometer over a belt of rounded gravel on low plateau land above the river-channel. About thirty-three kilometers southwest of Acary another similar belt, or possibly the extension of the same belt, half a kilometer wide, is crossed by the road. Much, if not all, of the quartz-gravel of the vicinity may be derived from the numerous quartz and pegmatite ledges; but some cause other than simple disintegration would seem necessary for the production of the wide belts of rounded material. It is possible that what seemed to be wide bands of gravel were places where the road followed nearly along narrow bands through the dense scrub; but it is improbable that the road would have been deliberately cut along such paths of rough going for beasts of burden.

In the lowland along Rio Apody near Mossoró several bands of quartz-gravel were crossed, the relation of which either to the present stream-channel or to the adjacent bluffs of Cretaceous limestone was not clear.

[44] Crandall (Publ. No. 4 of the *Inspectoria*, p. 29), noted these gravels, but he seems to have associated them with sedimentary deposits in a Cretaceous basin in Serra do Teixeira, to the southwest.

Near Santo Antonio a band of quartz-gravel fifty meters wide extends about parallel with the Rio Palhano at a distance of three kilometers from it, and low slopes bordering the river are also partially covered with similar gravel.

Quartz-gravel borders the northern side of the valley land near Limoeiro, but seems not to be suggestively located with respect to the present stream-channels. Rio Jaguaribe and Rio Banabuiu each has a sandy channel, from two hundred to three hundred meters wide, cut from three to five meters deep in the alluvium of the valley.

For several kilometers southwest of Angicos, and also between Paú dos Ferros and Reservoir Sant' Anna angular quartz-gravel is scattered over the surface, being apparently derived from numerous small quartz veins which traverse the gneiss and schist.

About eight kilometers south of Cratheús rounded quartz-gravel covers the surface for half a kilometer. The deposit is near a small area of crystalline limestone of the Ceará Series, to which the gravel may be related.

Near the eastern border of Nazareth (northwest of Recife), there is coarse gravel composed of quartz pebbles. Farther north, between Cobé and Independencia, Dr. Branner observed gravels, partially imbedded in the soil, which seem to belong with the sedimentary series, which at that point overlies the bedrock.[45] The gravels near Nazareth may also be remnants of the coastal sedimentary beds.

Dr. Branner also records the occurrence of gravels farther south in Pernambuco, and in Alagôas, as follows:[46] "The country from the Rio São Francisco at Pão d'Assucar to Aguas Bellas, in the State of Pernambuco, and thence to Pedra Pintada, ten leagues northeast of Aguas Bellas, is all of crystalline rocks, mostly granites, gneisses and schists, with a few occurrences of marble. Over the surface of these rocks are here and there patches of a thin layer of water-worn materials of various sizes and mostly of quartz. The worn materials are not confined to the stream-channels or to the valleys, but spread alike over high as well as low ground."

In the basin of the Rio Itapicurú between Queimadas and Jacobina

[45] *Geology of the Northeast Coast of Brazil*, pp. 54–55.

[46] *On the Occurrence of Fossil Remains of Mammals in the Interior of the States of Pernambuco and Alagôas, Brazil*, by John C. Branner, *Am. Jour. Sci.*, Feb., 1902, p. 134.

there are numerous patches of quartz-gravel, which seem to be derived from near-by, or perhaps underlying, beds of quartzite or dikes of pegmatite.

In the places where the material is merely scattered over the surface as subangular fragments in localities, where quartz-bearing beds, veins, or dikes are present, the source of the gravel seems to be evident. But where broad bands of more or less rounded gravel occur, as in the vicinity of Jardim de Seridó, with no evident connection either with immediate sources of the material or with stream courses, their origin must be sought either in an ancient sedimentary series, or in ancient drainage-systems.

Basic Igneous Rocks. The Brazilian Complex, which forms the basement-rock of most of the region, and is exposed at the surface over large areas, consists of numerous varieties of plutonic, metamorphic, and dike-rocks. Little petrographic study of them has yet been carried on, but Jenkins[47] describes from the vicinity of Baixa Verde in Rio Grande do Norte, a quartzitic arkose, a quartz-biotite schist, two biotite schists, a granite haplite, granite pegmatites, and dikes of granite. A petrographic slide of rock from near the city of Bahia was examined for the writer by E. S. Larsen, Jr., who found it to be probably a granodiorite, somewhat crushed and banded. The rock contains plentiful quartz, much plagioclase feldspar (andesine), and some orthoclase, with much biotite, usual amounts of magnetite and augite, and pyroxene as alteration material. The rock also contains veinlets of sericitized material. An unusual feature is the presence of abundant, large, prominent zircons. It will be noted that all these petrographic descriptions are of acid rocks.

Haplites, pegmatites, and other acid dike-rocks seem to be common, but the more basic rocks are believed by the writer to be relatively rare in the region under discussion. Farther west, in the State of Piauhy, basic rocks are less uncommon. Dr. M. A. R. Lisboa, found in that region two types of material, a compact diabase, and a trap.[48] The former is a normal diabase, exposed in the bottoms of valleys, where it has been uncovered by erosion. In some places it forms dikes or sheets; in others it is found as great rounded blocks scattered over

[47] *Geology of the Region about Natal, Rio Grande do Norte, Brazil*, by Olaf Pitt Jenkins, *Proc. Am. Phil. Soc.*, Sept.–Oct., 1913, pp. 12–14.

[48] *The Permian Geology of Northern Brazil*, by Miguel Arrojado R. Lisboa, *Am. Jour. Sci.*, May, 1914, pp. 432–433.

the surface of Permian sandstone. The trap is a pyroxene-bearing rock, with plagioclase, but is commonly amygdaloidal and rich in zeolites. It is considered to represent a later phase of the diabase, and occurs in places as extensive flows.

An example of the normal diabase was seen by the writer in the valley of the Rio Poty, thirty to forty kilometers west of Marvão, in Piauhy. At the base of Serra de Tucunduba in northwestern Ceará, Small[49] observed an intrusion of basic igneous rock, which he took to be diabase. Farther south in this State the writer crossed a band of dark, basic, porphyritic rock nearly a kilometer wide, about twenty kilometers north of Tauá. Half-way between Arneiroz and Saboeiro a narrow band of basic rock crosses the road, and twenty kilometers north of Assaré there is a wider band, which exhibits concentric weathering. In the state of Rio Grande do Norte a band of dark rock, possibly diabase, three hundred meters wide, crosses the road between Apody and Angicos; and a similar band fifty meters wide was noticed twenty-five kilometers farther south, between Angicos and Paú dos Ferros. To the south, in the State of Parahyba, a dike a meter wide, of dark, fine-grained rock, was seen near the road, ten kilometers north of Barriguda. About eighty kilometers to the southwest or three kilometers west of Nazareth, a band a few meters wide of dark rock, which was noted as 'gabbroid,' crosses the road. The seven occurrences noted by the writer in Ceará, Rio Grande do Norte and Parahyba are at the only places where basic materials were noticed by him, though watch was kept for such rocks. Hence the statement seems warranted that basic dike-rocks are not common in the region. No such occurrences were noticed in the State of Bahia, but so careful watch was not kept for them there.

Near Massapê, in northwestern Ceará, there is an area of basalt, which is crossed by the main road to Sant' Anna. Along this road the basalt extends from four and one-half kilometers east of Massapê for seven kilometers northeastward. The limits of the flow to the northwest and southeast are not known to the writer, but the extreme length or width of the lava-covered area is probably not more than ten or twelve kilometers. Along its western border, where the lava overlies sandstone (probably a basal portion of the Cretaceous rocks of Serra Grande), the sandstone is hardened, as if baked. The only other occurrence of similar lava that the writer knows of in the region

[49] Publ. No. 32 of the *Inspectoria*, p. 49.

is near Assú, four hundred kilometers to the southeast, where R. H. Soper found an area about one kilometer in diameter, dotted with basaltic boulders. A petrographic slide of a specimen of this rock, which was given to the writer by Mr. Soper, was examined by E. S. Larsen, Jr., who found the rock to be an ordinary basalt, with abundant large, slightly altered crystals of olivine. Plagioclase is plentiful as labradorite and there is considerable augite in small rods. Magnetite is also plentiful and some apatite is present. The matrix is pale yellow to colorless, part isotropic, part polarizing, probably glass.

Acid lavas are also very rare in the region. On the coast of Pernambuco Dr. Branner found trachyte at a headland known as Pedras Pretas, twenty-five kilometers south of Recife, and rhyolite on the little island of Santo Aleixo, thirty kilometers farther south.[50] Of the former he says "I recall no other occurrence of trachyte in Brazil."

Springs. The scarcity of springs in most of northeastern Brazil is notable. Even mere seepages, such as afford supply to prospectors and travelers in the desert portions of the southwestern United States, are rare in the great areas of crystalline rocks in northeastern Brazil. Throughout these areas, in localities away from the shallow underground supplies of the wide, sandy stream-channels, dependence is placed upon shallow reservoirs formed by earthen dams across the courses of small streams, or in laboriously excavated 'tanques,' which are also supplied by surface run-off. Within the crystalline areas only three ordinary or "hillside" springs were seen by the writer, near the border of Campina Grande, at Olho d'Agua (Spring) two kilometers north of Viração, and at Paú dos Ferros, a settlement of six or eight houses four kilometers north of Periquitos. All three springs are mere tricklets, which issue from the more or less crushed rocks of the Planalto da Borborema.

The great storage reservoirs formed by the Cretaceous sandstones of the highland areas of Serra Grande, Chapada do Araripe, Chapada do Apody, and minor areas, supply a number of springs, which issue from the bluffs; but not to the extent that might be expected. The city of Ipú, at the base of Serra Grande (Plate VIII, fig. 2) is supplied by springs which issue near the top of the range, two hundred and fifty meters above the city, and cascade down with a flow of from one hundred and fifty to two hundred liters per minute. Similar springs

[50] *Geology of the Northeast Coast of Brazil*, pp. 59–60 and 62.

along this serra are reported by Small[51] near São Benedicto, Ibiapina, Jacaré, and Viçosa.

From the bluffs above Jardim, at the southeastern base of Chapada do Araripe, twenty-seven springs are locally reported to issue. The largest has about the same flow as the supply at Ipú. It issues in full volume at the base of a bouldery sandstone cliff, ten or fifteen meters below the crest of the chapada, with a temperature of 26° C. (79° F.). Similar springs supply Crato and Sant' Anna do Cariry; but the western part of the chapada is not so well supplied with springs as the eastern part, possibly because the sandstone dips gently eastward and causes the underground supply to be more easily discharged in that direction.

On the southwestern side of Chapada do Apody the water supply of Curraes is furnished by a spring of about six liters per minute which issues ten meters below the top of the chapada, at the base of limestone cappings the sandstone beds. A similar spring issues from the same horizon at Olho d'Agua, four kilometers farther south. At Soledade, seven kilometers north of Apody, a spring which comes forth in a grotto in the limestone surface of the chapada, yields per minute five or six liters of hard, calcareous water; and Crandall[52] reports another spring five kilometers farther north, and two others on the west side of the chapada. He also records[53] eight springs on the northwestern flank of Serra do João do Valle, which is capped with the Cretaceous sandstone, and two springs on the southeastern flank of the adjacent small Serra de Acauan.

Thermal, and notably mineralized, springs are rare. The occurrence of only two springs of each class, aside from the spring of calcareous water at Soledade, are known to the writer: the thermal springs at Brejo, in Parahyba and at Sipó, in Bahia; and the carbonated springs at Fazenda Caché, in Piauhy and Olho d' Agua Encantada, near Mossoró, in Rio Grande do Norte. Only the first-mentioned was visited by the writer. They are situated ten kilometers north-northwest of São João, at the base of a granitic hill, at the north border of an area of Cretaceous sandstone. A close contact between fine-grained, white (possibly leached) sandstone and the granite is exposed near the springs. There are three springs, which issue a few meters

[51] Publ. No. 32 of the *Inspectoria*, pp. 119–120.

[52] Publ. No. 4 of the *Inspectoria*, p. 40.

[53] Idem, pp. 36–37.

apart, having respectively flows of about two and one-half, one-half and one-third liter per minute. The water is slightly sulphuretted and tastes slightly sweetish. The springs are protected by curbing and shelters, and have long been used for medicinal bathing. The temperature of the water, 36° C., (97° F.), and the abnormally steep dip of the sandstone at the locality indicate that the water may rise along a fault plane.

The spring on Fazenda Caché, fifteen kilometers southwest of São João do Piauhy, or about eighty kilometers southwest of Simplicio Mendes (in the southwestern corner of map (Pl. IV) was visited by Small,[54] who found that although it is locally called a hot spring, the temperature does not seem to be abnormal, the term being applied because of the escape of gas, probably carbon-dioxide, which gives the water the appearance of boiling. The water rises in a shallow pool of slight overflow, at the base of sandstone slopes, just above the contact of the sandstone with underlying calcareous shale.

Olho d' Agua Encantada (Enchanted Spring), a few kilometers east of Mossoró, has been noted by Crandall,[55] who says that it is regarded by the people as being very extraordinary, because of the alternate appearance and disappearance of the water, and because at times they are unable to enter the grotto where the water issues, due to the gas, which is given off. He states that evidently there is here a production of carbonic acid gas, which alternately causes the spring to flow, by forcing the water up, and then escapes and itself fills the grotto.

[54] Publ. No. 32 of the *Inspectoria*, p. 144.

[55] Publ. No. 4 of the *Inspectoria*, pp. 41–42.

APPENDIX.

FOSSIL MAMMALS COLLECTED AT PEDRA VERMELHA, BAHIA, BRAZIL, BY GERALD A. WARING.

By W. J. Holland.

Introductory.

On my journey to Argentina in the autumn of the year 1912[56] I formed the acquaintance on shipboard of Mr. Gerald A. Waring, who took passage at Bahia and went with us as far as Rio de Janeiro. In the course of conversation he told me of his discovery at Pedra Vermelha of a considerable deposit of fossil remains and kindly presented me with some interesting fragments, which he had in his possession at the time, promising at a later date to send to the Carnegie Museum the remainder of the specimens, which he had collected, and which he had left in storage at Bahia. This promise he subsequently fulfilled, sending to the Museum a large box containing a number of specimens.

The fragments given to me on shipboard by Mr. Waring were taken by me to La Plata, where I had an opportunity to compare them with the fine material preserved in the National Museum at that place, receiving the assistance in so doing of Dr. Santiago Roth, the learned and amiable Curator of Fossil Vertebrates. The larger collection, subsequently received, was under my direction unpacked by my assistant, Mr. O. A. Peterson, who devoted some time to their preliminary study, accessing them, and assigning to them numbers in the Catalog of Fossil Vertebrates in the Museum. I am thus indebted to Mr. Peterson for having lightened the task of preparing the list, which will be presented in the following pages. The entire collection is accessed under the Number 4759, and falls into the Catalog of Fossil Vertebrates under the Numbers 11028–11035 inclusive.

Before presenting the record of the material it is proper to state, that, as nearly as I can now recall the oral account given me by Mr.

[56] *To the River Plate and Back*, by W. J. Holland, 1913, G. P. Putman's Sons, New York, pp. 1–387.

Waring, the remains were uncovered by some workmen, who were engaged in enlarging and cleaning out a "water-hole," to which it was their custom to drive cattle to drink. The supply of water in this region, as the foregoing paper shows, is very limited, and wells are evidently as precious as they were in Palestine in the days of the Biblical Patriarchs. Professor J. C. Branner in *The American Journal of Science*, 1902, pp. 133–137, has brought together a number of references to the occurrence of fossil mammalian remains found under like circumstances at other localities in the same general region. He tells us that at Lagoa da Lagea, a spot about about two hundred miles to the northeast of Pedra Vermelha, about a ton of fossil bones and teeth were excavated in 1873 during the digging of a reservoir upon this cattle-ranch. He subsequently visited the spot and gathered together enough of the material to make loads for three horses, and sent what he had picked up to the Geological Museum at Rio de Janeiro. He tells us that the bones were worn and abraded, as if they had been trampled under foot by other animals long before they were excavated. He states that they were the bones of large animals, of which only those of a mastodon were identified. A human artefact in the form of a stone pestle was reported to have been found associated with these remains. Dr. Branner mentions another locality, not far distant from Lagoa da Lagea, named Lagoa Cavada, where the discovery of fossil bones was reported to have occurred, but where his personal examination failed to reveal their presence. He tells us that "many cases have been reported of finding such remains under similar circumstances in the States of Alagôas, Pernambuco, Parahyba, Rio Grande do Norte, and Ceará, and it seems probable that they may be found throughout the entire area of Brazil that is subject to droughts."

That these fossils are of Pleistocene age seems not to admit of question. They occur in beds of gravel lying in depressions of the primitive rocks, granite and gneiss, in which soil formed by erosion has gathered, and which undoubtedly contained long ago, as they still contain, accumulated surface-water. The animals of the past resorted to these drinking places and died there, as do the cattle today, in periods of drought. The conditions were evidently such as J. W. Gregory, [57] quoted by Dr. Branner,[58] points out to be still the case in

[57] J. W. Gregory, *The Great Rift Valley*, 1896, pp. 268–9.

[58] J. C. Branner, *American Journal of Science*, (4) XIII, 1902, p. 137.

Africa. They recall to my mind the conditions, which occur at the famous Agate Springs Fossil Quarries, from which the Carnegie Museum and later the University of Nebraska and the American Museum of Natural History in New York have derived a wealth of mammalian remains dating from the Miocene. The occurrence of great quantities of bones at these spots is attributable not to floods so much as to droughts, which caused the creatures to come age after age to the water-pools, where they died and their remains were buried in the sand and mud surrounding the drinking-pools. Here also they were no doubt often the prey of carnivores, which found at once meat and drink at these places. Some died of old age and disease, others were perhaps mired in quick-sands. Thus from a combination of causes working together these great accumulations of bones were gradually formed.

It is much to be wished, as Dr. Branner has already intimated, that a careful and thoroughly systematic exploration of all these localities in Brazil may be made by competent paleontologists, prepared to collect in a systematic and intelligent manner. Such explorations would undoubtedly result in adding a vast amount of important information to the still exceedingly scanty records which we possess as to the extinct mammalian fauna of Brazil, a region which once possessed a vast and remarkable fauna, which has completely vanished.

Class **MAMMALIA.**

Order *CARNIVORA.*

Family FELIDÆ.

Subfamily MACHÆRODINÆ.

Genus **Smilodon** Lund.

Smilodon neogæus Lund (?)

I refer with doubt to this species a fragment (No. 11031) which appears to me to be a bit of the rib of a large carnivore. It is only 8 cm. in length.

Order *UNGULATA*.

Suborder TOXODONTIA.

Family TOXODONTIDÆ.

Genus **Toxodon** Owen.

Toxodon burmeisteri Giebel.

Among the fragments given me by Mr. Waring on shipboard are a broken upper molar (No. 11034) and a fragmentary upper (?) premolar (No. 11034*a*) which are referred to this species. The specimens were carefully compared with the material in the National Museum at La Plata, under the eyes of Dr. Santiago Roth, and I have no doubt as to the correctness of the determination. Associated with these teeth are some small fragments of other teeth, which no doubt belonged to the same species, if not to the same individual, as they were picked up at the same spot. They are mere flakes and chips.

It should be noted in this connection that Professor Cope established a species of *Toxodon*, to which he gave the specific name *compressidens*, the type of which came from "the northeastern part of the Province of Bahia," and therefore from the same general region as the material upon which I am reporting. The type of *Toxodon compressidens* Cope consists of "the incisors of the first and second places of the upper jaw." As the material at my command does not permit of comparison, belonging, as it does, to the molar and premolar series, and, as it seemed on comparison with well-determined material not to differ from the teeth of *T. burmeisteri*, I have determined not to make a queried reference to Cope's species, which the locality might suggest. I am the more persuaded not to do so, because Leidy[59] reports *Toxodon burmeisteri* from a small collection of fossils obtained in the northern part of Nicaragua, being represented therein by a nearly complete molar tooth and two portions of a lower incisor. *Toxodon burmeisteri* appears to have had a wide range extending from Argentina to Central America.

In addition to the teeth of which I have spoken there are fragments of some other bones evidently representing *Toxodon*, and presumably the same species. They are listed as follows:

Fragment of symphysis of lower jaw (No. 11034*b*)

Two fragments of arch of dorsal vertebra (No. 11034*c*)

Distal end of right femur (No. 11034*d*)

[59] Leidy, *Proc. Acad. Nat. Sci. Philada.*, 1886, p. 276.

Head of femur (No. 11034*e*). This specimen is only the articulating surface of a femur, with so little of the adjoining parts attached, as to make it difficult to decide to which side it belonged, although I am inclined to think that it represents the right femur, but not of the same individual as that to which the fragment No. 11034*d* belonged, being too large apparently to have been a part of the same bone.

Suborder PROBOSCIDEA.

Family ELEPHANTIDÆ.

Genus **Mastodon** Cuvier.

Some of the material is quite fragmentary, consisting of broken bits of the cusps of teeth, the exact location of which could only be determined by the expenditure of time which may be more profitably employed. Of these fragments, unidentified as to their locality in the dental formula, we list Nos. 11033*b*, *c*, *d*, and *e*. They are mere chips.

No. 11033*a* is the extremity of a small tusk, about 14 cm. in length, and about 5 cm. in diameter where broken off. One side shows considerable wear.

No. 11033*h* is a broken fragment of somewhat decomposed ivory, representing a large tusk, which probably was derived from about the middle of the tusk, which may have had a diameter of as much as five or six inches.

No. 11033*i* is a portion of a right upper jaw, in which there is imbedded a greatly fractured and abraded posterior molar, so much injured as to make the description of the cusps and valleys impossible. The tooth has an antero-posterior length of 180 mm. and a greatest breadth of 70 mm. It was long and relatively narrow. The fragment gives no evidence that this tooth was preceded by another, and, if such a tooth existed, it must have been separated from the one behind it by a wide diastema, which would be an unusual occurrence.

The most interesting specimen is a fragment of a right lower jaw of a Mastodon, No. 11033*j*. It discloses the presence of three teeth, of which the hindermost is only represented by the anterior margin of the vacant alveole. The middle tooth is greatly fractured. It had an antero-posterior length over all of 127 mm. and a width of 65 mm. There apparently were three transverse ridges of considerable height, intercalated between which on the median line were accessory cusps,

two in each interval, almost touching each other, and rising to a height sufficient to make their upper surfaces subject to the same wear as the transverse ridges. The anterior tooth was much smaller and only the roots remain imbedded in the alveole. The shape and the curvature of this fragment show that the animal had a short lower jaw, the first tooth of the series being only removed at its anterior margin a relatively short distance from the symphysis.

The structure of the teeth, so far as preserved in this particular specimen, seems to confirm the statement made by Schlesinger[60] that the South American species representing the group are more nearly related to *M. angustidens* than to other European species. However, the apparent shortness of the lower jaw seems to indicate a nearer approach to *M. americanum* than apparently is the case with other remains which have been described from South America, most of which have been referred to Cope's genus *Dibelodon*. The specific reference to any of the species, which have been described from the South American Pleistocene, does not seem possible, and it may be said with certainty that the specimen undoubtedly is not conspecific with *M. bolivianus* or *M. chilensis* of Phillippi, and certainly not with the species described from the Pliocene by other writers, and which have been, as already pointed out, referred to *Dibelodon*. It is quite probable that we are dealing in this case with a hitherto undescribed brachygnathous form, and at the risk, perhaps, of creating a synonym, I venture to propose for it the specific name *M. waringi*, in honor of the collector of these remains.

Another fragment is the distal extremity of the right tibia of a Mastodon of considerable size, No. 11033*g*. This bone shows a fresh fracture and undoubtedly more of the specimen might have been recovered, had the workmen realized the value of the material which they were taking up.

Genus? sp.?

There is a fragment of a tooth which suggests in a very general way that it may have belonged to a Proboscidean, (No. 11033*f*) but I am not able to identify it with anything heretofore figured or described. Mr. Peterson has in conversation urged that it may possibly be a part of the tooth of a young Mastodon, but I disagree with him.

[60] Schlesinger, *Die Mastodonten des K. K. Naturhistorischen Hofmuseums*, Denkschriften des K. K. Naturhistorischen Hofmuseums, Band I, Geologische-Paläontologische Reihe I, 1917, pp. 229–230.

We have the milk-teeth of *M. americanum*, both erupted and immature, before us for comparison, and I cannot bring myself to see that this fragment could possibly be so referred. The fragment shows in the first place such wear as to indicate that the animal was not very

Fig. 4. Fragment of tooth of Proboscidean (?) C. M. Cat. Vert. Foss., No. 11033*f*. Natural Size.

young. The most remarkable feature, however, is the corrugated surface of the outer enamel, which reveals deep striæ or irregular grooves and between them quite elevated rugæ, or elevations, which tend to converge at the extremity of the cusp. I herewith give a sketch of this fragment. It may be that some of my fellow-students can indicate to me what it may represent, but thus far I am unable to identify it with anything which I have found figured or described in the literature of the subject. Some of the older writers would, I imagine, have erected a genus and a species upon this thing, but we are coming in these later days to act more prudently and with greater reserve. Even the reference to the *Proboscidea* may be in error.

SUBORDER PERISSODACTYLA.

Family EQUIDÆ.

Genus? sp.?

There is an upper molar (No. 11032) somewhat broken, ($M^{\frac{1}{2}}$?) which seems to be referable to, if not the same as, *Equus rectidens* H. Gerv. & Ameghino. (*Cf.* Ameghino, *Los Mamiferos Fosiles de la Republica Argentina*, p. 505, Pl. XXVII, fig. 8.) We also have the lower molar of a horse, which may, or may not, belong to the same species, but which is indeterminable, the tooth being badly injured

(No. 11032*a*). Judging from the size of these teeth, the animals, which possessed them, were about the size of a zebra.

Order *EDENTATA*.

SUBORDER XENARTHRA.

Family MEGATHERIIDÆ.

Genus **Megatherium** Cuvier.

There are a number of fragments, which are undoubtedly referable to the genus *Megatherium*, and which in size, as well as in outline, compare well with those of *M. americanum* Cuvier.

These fragments have been cataloged as follows:

1. First sternebra (manubrium) rather well preserved and of large size. (No. 11029*a*).
2. Portion of atlas (?) (No. 11029*b*).
3. Fragment of shaft of humerus (No. 11029*c*).
4. Broken upper end of left ulna (No. 11029*d*).
5. Nearly perfect metacarpal IV of left fore foot (No. 11029*e*).
6. Piece of head of femur (No. 11029*f*).
7. Distal end of femur (No. 11029*g*).
8. Distal end of right tibia (No. 11029*h*).
9. Fairly well-preserved right astragalus (No. 11029*i*).
10. Distal end of clavicle (No. 11029*j*).
11. Fragments of ribs (No. 11029*k*).

Whether these *disjecta membra* all belonged to one and the same individual is open to grave question. It seems improbable. Whether the fragments of ribs are also all referable to *Megatherium* may also be disputed. The ribs, or what remains of them, are too much broken and imperfect to permit of a positive decision. Some of the bits may have belonged to other animals mentioned in this paper.

Genus? sp.?

Considerable time has been spent in the attempt to identify a fragment of the right lower jaw of what evidently was a large ground-sloth (No. 11028). It cannot well be referred to *Megatherium* on account of the apparently relative shallowness of the ramus (although on the lower side it has been broken and its exact depth is not definitely ascertainable). A stronger reason for not placing the fragment in *Megatherium* is the lack of the spout-shaped projection which occurs

in the region of the symphysis in the genus *Megatherium*. The specimen preserves the right border of the symphysis about to the median line.

SUBORDER LORICATA.

Family GLYPTODONTIDÆ.

Genus? sp.?

This group of animals is represented by several fragments of the coösified plates of the carapace or exoskeleton of one or more species. They have been assigned the number 11030 in the Carnegie Museum Catalog of Fossil Vertebrates. If the National Museum of La Plata were easily accessible, it is quite possible that we might be able to approximately locate these bits of bones in their proper place in the system of classification.

INCERTÆ SEDIS.

Under No. 11035, Carnegie Museum Catalog of Fossil Vertebrates, we have placed several broken and much abraded centra of vertebræ, which are indeterminable. They may represent parts of some of the animals hereinbefore mentioned, or they may not. *Quien sabe?*

Among the undetermined and apparently at the present moment indeterminable material in the collection is a piece of what seems to be the shaft of the tibia of a large ground-sloth. It cannot be referred to *Megatherium*. In size, but not in outline, it is large enough to have belonged to a very large Megatherium. It is inexpedient at present to attempt to place it more definitely.

ANNALS

OF THE

CARNEGIE MUSEUM

VOLUME XIII, NOS. 3–4.

Editorial Notes.

The general collections of the Museum in its various sections have been greatly enlarged during the past months by gifts, collections made by members of the staff, and by a few purchases. There have also been numerous loans of interesting and valuable collections which have been duly displayed. The collections either owned by the Museum or deposited in its custody, according to the last Annual Report of the Director, represent a monetary value of $1,737,355.49.

The educational work of the Museum in liaison with the public schools, the colleges of western Pennsylvania, and the University of Pittsburgh is constantly assuming greater proportions, and its resources are being heavily taxed to meet the demands made upon it. To comply with these demands is particularly difficult, because of the amount of time which requires to be expended both by the Director and his associates in directly acting as instructors, or in responding to the almost innumerable written requests for information which are made.

Museums, such as the Carnegie Museum, find themselves called upon in these days to function very much like libraries, as fountains of information for the general public; with this difference, that in a Museum *things* take the place of *books*. There is a constantly growing number of persons, who, rather than read about, or look at

pictures of objects, demand to be shown the objects themselves. This desire is most natural and laudable, but its gratification entails upon the staff of every Museum a vast amount of work, which consumes time, but which can not be avoided, even with the best arrangement of exhibits and labels. This is a fact which those who are not familiar with the administration of a Museum often fail to realize.

VOLUME VIII of the *Memoirs* of the Museum has passed through the press and has been published in bound form, separates of the different papers therein having long since been issued. The volume contains three memoirs, the first of which upon the *Naiades of Pennsylvania,* is the conclusion of Dr. Ortmann's work upon this subject; the second memoir is from the pen of Dr. O. E. Jennings, and is a report upon the fossil plants collected by Mr. Douglass in the beds of volcanic ash near Missoula, Montana; the third memoir, completing the volume, is a monographic paper upon the *Naiades* (mussel-shells) of the South American continent, prepared by Dr. A. E. Ortmann.

While the collection of South American *Naiades* in the possession of the Carnegie Museum is far from being complete, it is, nevertheless, very large, and is quite exceptional in that it probably preserves to a greater extent than any other collection in existence the animals which deposit the shells, the so-called "soft parts." In past time the greater part of conchological work dealing with classification has been based almost exclusively upon the "hard parts," the shells themselves, without reference to the structure of the living animal which constructs and inhabits them. Dr. Ortmann's paper possesses the merit of being the first publication upon the mussel-shells of South America, which treats of the subject from the broader point of view, giving an account of the anatomical structure of the animals which form the shells.

AMONG the notable events which have taken place since the last issue of the ANNALS was the visit of Madame Marie Curie to Pittsburgh.

It fell to the lot of the Director of the Carnegie Museum to be chosen as the chairman of the committee appointed in Pittsburgh to

solicit funds for securing the gram of radium, intended to be a gift to Madame Curie from the women of America, and to make arrangements for her visit to this city. In this work the Director found himself at the head of an organization of ladies and gentlemen whose willing coöperation insured success.

It was resolved to make all contributors to the fund members of the General Reception Committee. The work of attending to details was assigned to an Executive Committee of Ladies, at the head of which was Mrs. Henry R. Rea, and a Committee of Gentlemen, at the head of which was the writer of these lines. It is needless to say that with Mrs. Rea at the head of the Committee of Ladies and with Mr. James C. Gray, the President of The Standard Chemical Company, the principal manufacturers of radium in the world, on the Committee of Gentlemen, success was inevitable.

In response to an appeal sent out by the Chairman, contributions in cash amounting to $12,780.76 were received, of which $10,196.25 were remitted to the General Treasury in New York and $2,584.51 were paid directly to Madam Curie. In estimating the contribution made by Pittsburgh, there should be added to the foregoing total the amount given by The Standard Chemical Company through Mr. Gray, they having, in fact, contributed the sum of over fifty thousand dollars. All incidental expenses were born by the members of the Committee of Ladies and Gentlemen without any deduction from the funds contributed. The Standard Chemical Company also constructed a novel and costly receptacle to contain the radium, the inscription on which, engraved upon a gold plate, was as follows:

PRESENTED BY THE PRESIDENT OF THE
UNITED STATES OF AMERICA ON BEHALF
OF THE WOMEN OF AMERICA
TO
MADAME MARIE SKLODOWSKA CURIE
IN RECOGNITION OF HER TRANSCENDENT
SERVICE TO SCIENCE AND TO HUMANITY
IN THE DISCOVERY OF RADIUM.
THE WHITE HOUSE, WASHINGTON, D. C.
MAY TWENTIETH, NINETEEN TWENTY-ONE

The case is opened by a gold key suspended from a ribbon. The key

and the case were delivered to Madame Curie at the White House on the afternoon of May 20, 1921, by the President of the United States, and the precious receptacle with its more precious contents is now safely in Paris.

Madame Curie received the honorary degree of Doctor of Laws at the University of Pittsburgh in the presence of a gathering of more than twenty-five hundred persons assembled in the Soldiers' and Sailors' Memorial Hall. The pleasant duty of presenting her for the degree devolved upon the Director of the Carnegie Museum. After this ceremony Madame Curie, accompanied by her daughters, met the members of the Reception Committee in the foyer of the Hall of Music at the Carnegie Institute, and later took her place upon the platform, where she was introduced to those who were unable to clasp her hand. An interesting incident was the presentation to her on the platform of a souvenir of her visit to Pittsburgh, given to her by the Polish women of western Pennsylvania, and handed to her by a young Polish girl in national costume, who was attended by a party of other young ladies similarly attired.

Madame Curie, of course, visited the great establishment where the gram of radium which she had received had been made, and she was the recipient of such social attentions as the condition of her health and the brief limits of her stay made possible. She and her daughters and the party accompanying them were the guests during their visit of Mrs. Henry R. Rea in her beautiful home on Sewickley Heights.

Madame Curie on her return to France carried back with her not only the gram of radium presented by the women of America, but $22,000 worth of mesothorium and other valuable ores, bringing her precious package up to the value of $162,000.

In a letter to the writer of these lines received from Mrs. Marie M. Meloney, to whom the credit of the whole enterprise is due, Mrs. Meloney says: "In addition to this she had in cash from awards of scientific societies in this country $6,884.51. There is $52,000 left in the Equitable Trust Company. We are holding this pending the completion of the fund suggested by a prominent American gentleman, who offered to collect $50,000 for the equipment for Madame Curie's laboratory, if the women on the Executive Committee desired to establish an American trust with the money remaining in the bank, which would provide Madame Curie with an income as long as she lives.

It was proposed that after her death the income from this trust be used to pay the expenses of two American students in chemistry and physics at the Sorbonne."

Madame Curie took with her from America not merely the tangible and substantial evidence of the esteem of the American people, to which reference has been made, but their good-will and affection, which will follow her all the days of her life, which we hope may be many.

SINCE the first part of the present volume of the ANNALS was sent to press, death has removed two well-known members of the Board of Trustees of the Carnegie Institute, both of whom served on the Committee upon the Museum.

On April 8, 1920, Dr. John Alfred Brashear passed away after a long and distinguished life of usefulness. He served as a member of the Committee on the Museum from 1897 to 1901.

On April 10, 1921, Mr. Henry Kirke Porter, who had been a member of the Board of Trustees of the Carnegie Library and of the Institute from the beginning, having been one of Mr. Carnegie's original appointees, died in the eighty-first year of his age. He was appointed a member of the Committee on the Museum in 1920, but never attended a meeting, being prevented from so doing by his residence in Washington, D. C.

Both of these eminent gentlemen rendered distinguished service to the Institute, and their names will always be held in grateful remembrance.

ON November 22, 1920, Miss Mary Jane Stribling, the oldest member of the staff of the Museum in point of actual service, died after a lingering illness. She belonged to an old and distinguished family of Virginians, and had received in her early life an excellent education. Compelled by adversity to make her own livelihood, she became a stenographer and for a long period was in the employment of one of the leading firms of music-dealers in Richmond, Va. On the occasion of a visit to Pittsburgh, where she had friends, they induced her to endeavor to secure employment in Pittsburgh, and accordingly she applied to Mr. C. C. Mellor, then the chairman of the Committee

on the Museum and the head of the leading firm of music-dealers in Pittsburgh, of whom she knew something. Mr. Mellor was so favorably impressed that he at once, after conference with the Committee on the Museum, recommended her appointment. This was at the time of the inception of the work of the Museum, before a director had been elected. She accepted the appointment and began her work by aiding Mr. Mellor in attending to the correspondence. Thenceforward from 1897 until the end came she was a member of the staff of the Museum. She was a good linguist, capable of receiving dictation in French, German, and Spanish, as well as in English. She possessed literary taste, and familiarized herself very soon with the scientific nomenclature, which is necessarily largely employed in the correspondence of a Museum. She was discreet and most loyal to her friends and employers. All in all she was a rather remarkable woman of high attainments and character, and her death deeply saddened the circle of friends who immediately surrounded her.

THOUGH for many years not connected with the Carnegie Museum, Dr. John Adolph Shafer was one of the earliest members of its staff, and it is proper that record should be made of his death, which occurred in the Sewickley Valley Hospital on February 1, 1918, in the fifty-sixth year of his age, he having been born on February 23, 1863.

Dr. Shafer was an enthusiastic field collector and one of the leading members of the Western Pennsylvania Botanical Society. He had charge of the Herbarium of the Carnegie Museum from 1897 until 1904, when he received an appointment as a Custodian in the New York Botanical Garden, a position which he held until 1910. He made many journeys to the American tropics, both during and after his appointment in New York, and cheerfully endured many hardships in his pursuit of specimens. His death was probably the result of an infection by some obscure disease contracted by him in northern Argentina and Paraguay on the occasion of his last expedition.

While but little from his pen has been published, he is credited with the discovery of many new plants. Two genera and twenty-five species have been named after him by systematists. In the first volume of these ANNALS there was published "A Preliminary List of the

Vascular Flora of Allegheny County, Pennsylvania," which he prepared, and in which he enumerates one thousand one hundred and ninety-four species. This list in recent years has been considerably enlarged by the discovery of additional endemic species.

A detailed account of his life and various activities has been published by Dr. O. E. Jennings in *Trillia,* No. 5 (1919), pp. 3–7, and by Dr. N. L. Britton in the *Journal of the New York Botanical Garden,* Vol. XIX, pp. 97–99.

The writer of these lines recalls the last visit paid to him by Dr. Shafer shortly after his return from his final South American journey. I spoke of the giant cacti found on the eastern foothills of the Andes, and expressed my wonder at their enormous size, some of them being trees from forty to fifty feet in height. He instantly warmed up and grew enthusiastic. "Say, did you ever dream there could be such cacti? I was amazed at their size. The world does not realize how wonderful they are. I have just come from wandering about among them, whole forests of them. To my mind they are quite as wonderful as the 'big trees' of California, and I agree with you that, before they are cut down, the people of Argentina should create a reservation, preserving some of these giants of the vegetable world for future generations to admire."

Dr. Shafer was twice married and leaves a widow and eleven children to mourn his loss.

VI. A REVIEW OF THE FISHES OF THE FAMILY MUGILIDÆ FOUND IN THE WATERS OF FORMOSA.

By Masamitsu Ôshima, Ph.D.

(Pls. XI, XII, and XIII, fig. 1.)

The present paper gives an account of the species of fishes belonging to the family *Mugilidæ* found in the waters of the Island of Formosa. It is based on the collections of the author, preserved in the Museum of the Institute of Science of the Government of Formosa, a series also being sent to the Carnegie Museum, including the types of the new species. Of the ten species the four following seem to be new to science:

1. *Mugil anpinensis,*
2. *Liza formosæ,*
3. *Liza pescadorensis,*
4. *Liza parva.*

I am indebted to Dr. David Starr Jordan for help in the preparation of this paper.

Family MUGILIDÆ.

(The Mullets.)

Body oblong, more or less compressed, covered with rather large cycloid scales; no lateral line, but the furrows often deepened on the middle of each scale, so as to form lateral streaks; mouth small, the jaws with small teeth, or none; the teeth, if present, mostly loosely attached, often ciliiform; premaxillaries protractile; gill-openings wide, the membranes separate, free from the isthmus; branchiostegals five or six, gill-rakers long and slender; gills four, a slit behind the fourth; pseudobranchiæ large; two short dorsal fins, well separated, the anterior with four stiff spines, the last one of which is much shorter than the others; second dorsal longer than the first, similar to anal; anal spines usually three (two in the genus *Querimana*) graduated; ventral fin abdominal, not far back, composed of a stiff spine and five rays; caudal forked; air-bladder large, simple; intestinal canal long; peritoneum usually black; vertebræ twenty-four. Genera about ten, species about one hundred, inhabiting fresh waters and coasts of warm regions, feeding on organic matters contained in mud.

KEY TO GENERA FOUND IN FORMOSA.

a. Anal spines three; stomach gizzard-like. Species marine.
a'. Adipose eye-lid well developed, covering at least a third of the iris posteriorly ..... *Mugil*, 1.
a''. Adipose eye-lid not developed.
b. Upper lip thick, moderately developed ..... *Liza*, 2.
bb. Upper lip greatly thickened ..... *Chelon*, 3.

1. Genus MUGIL (Artedi) Linnæus.

1758. *Mugil* (Artedi) LINNÆUS, Syst. Nat., Ed. X, p. 316. (Type, *Mugil cephalus* LINNÆUS.)

Body oblong, compressed, covered with large cycloid scales. Mouth more or less transverse; the upper lip moderate; anterior margin of the mandible sharp. Both jaws with a few series of small, flexible, ciliiform teeth. Eyes lateral, each with well-developed adipose eye-lid. Stomach gizzard-like. Anal fin slightly longer than the second dorsal.

Distribution: Migratory fishes of all the temperate and tropical regions, often entering rivers. These fishes are known in Japan as *Bora*.

KEY TO FORMOSAN SPECIES OF MUGIL.

A. Anal fin with eight soft rays.
a^1. Median dorsal line not carinated.
b^1. Mandibular angle obtuse; extremity of maxillary entirely hidden; adipose eye-lid well developed, covering the iris.
c^1. 40–42 scales in a lateral series; depth less than 5 in the total length ..... *cephalus*, 1.
c^2. 38–39 scales in a lateral series; depth more than 6 in the total length ..... *japonicus*, 2.
b^2. Mandibular angle obtuse; extremity of maxillary exposed; adipose eye-lid thin, not covering the iris.
c^1. 28 scales in a lateral series ..... *anpinensis*, 3.
a^2. Median dorsal line carinated in front and back of the spinous dorsal.
b^1. Mandibular angle obtuse; 38 scales in a lateral series. *carinatus*, 4.

B. Anal fin with nine soft rays.
d. 33 scales in a lateral series; extremity of maxillary entirely hidden; pectoral nearly as long as head, extending to the spinous dorsal ..... *kelaartii*, 5.

1. **Mugil cephalus** Linnæus.

1758. *Mugil cephalus* LINNÆUS, Syst. Nat., Ed. X, p. 316; Europe.—CUVIER & VALENCIENNES, Hist. Nat. Poiss., XI, 1830, p. 307.—GÜNTHER, Cat. Fish., III, 1861, p. 417; Mediterranean; Coast of Madeira; Nile; fresh-water lakes of Tunis; west coast of Africa.—JORDAN & RICHARDSON, Bull. U. S. Bur. Fish., XXVII, 1908, p. 244; Calayan, P. I.—ÔSHIMA, Ann. Carneg. Mus., XII, Nos. 2–4, 1919, p. 268; Taihoku.

Head 3.86 in length; depth 4.42; D. IV–1, 8; A. III, 8; P. 17; V. I, 5; width of head 1.55 in its length; eye 4.23 in head; interorbital space 2; snout 3.50; first dorsal spine 2.20; depth of caudal peduncle 2.66; forty-two scales in a lateral series from gill-opening above to caudal base, thirteen scales in a transverse series counted from vent upward and backward to soft dorsal.

Body robust, elongate, somewhat compressed; dorsal profile nearly straight, ventral profile broadly rounded; head rather small, broad, its top depressed; snout short and obtuse, broadly rounded anteriorly; interorbital space broad, nearly flat; mouth subinferior, slightly oblique, its angle reaching a vertical through posterior nostril; cleft of mouth two times as broad as deep; mandibular angle obtuse; lips thin; lower jaw shorter than the upper, with rather sharp outer edge, symphysis forming a short keel, which fits into the corresponding concavity on the roof of the upper jaw; extremity of maxillary not exposed; both jaws with minute teeth along their outer edges, scarcely visible without lens; eyes anterior, hidden anteriorly and posteriorly by well-developed adipose eyelid; nostrils separated; anterior nostril in a very short tube; posterior nostril slit-like, in front of eye above.

Scales large, cycloid; head scaly, those on the top somewhat enlarged; soft dorsal, anal, and pectoral covered with small scales; base of the caudal fin covered with large scales varying in size; a pointed scaly flap along the base of spinous dorsal.

Origin of spinous dorsal midway between tip of snout and base of caudal; soft dorsal inserted behind the origin of anal, anterior ray the longest; pectoral reaching beyond the origin of ventral, but not reaching the spinous dorsal, inserted above the middle of body; ventral a little nearer the root of pectoral than the spinous dorsal; anal fin opposite the soft dorsal, inserted in advance of the origin of the latter; caudal fin forked.

Color in alcohol grayish above, lower parts silvery; sides with dark

longitudinal stripes along several rows of scales; pectorals, dorsals, and caudal dusky; ventrals and anal whitish.

Length of body 255 mm.

Described from a specimen from Daitôtei Fish Market, Taihoku, collected by Ôshima in March, 1917, and preserved in the Museum of the Institute of Science, Formosa. C. M. Cat. of Fishes, No. 8256.

Habitat: Probably our specimens (three) obtained at the Daitôtei Fish Market were captured at Tamusui near Taihoku.

Remarks: I have little doubt that the present species is true *M. cephalus,* because it agrees quite well with *Mugil cephalus* from Italy in the Stanford University Collections.

The common mullet of Japan, described by several authors under the name *Mugil cephalus,* is distinct from the present species in having a lower body and thirty-eight scales in a lateral series. As it also differs from *Mugil japonicus* Temminck & Schlegel from Nagasaki, covered with ctenoid scales instead of cycloid scales, it is reasonable to give a new name to the former.

2. **Mugil japonicus** Temminck & Schlegel.

Karasumi-bora (Japan); Oahii (Formosa).

1846. *Mugil japonicus* TEMMINCK & SCHLEGEL, Fauna Japonica, Poiss., p. 134, Pl. 72, Fig. 1; Nagasaki.—RICHARDSON, Ichth. China, 1846, p. 247; China.—BLEEKER, Verh. Bat. Gen., XXV, 1853, p. 41; Japan; Act. Soc. Sc. Indo-Neerl., VIII, 1860, p. 59; Borneo; Ned. Tijdschr. Dierk., IV, 1873, p. 143; China; Verh. Akad. Amsterdam, XVIII, 1879, p. 17; Japan.

1911. *Mugil cephalus* TANAKA (not of LINNÆUS), Fishes of Japan, p. 50, Pl. XIII, Figs. 42–45; Japan (one part).—JORDAN, SNYDER, & TANAKA, Journ. Coll. Sci. Tokyo, XXXIII, 1913, p. 113; Japan (one part).

1903. *Mugil oeur* JORDAN & EVERMANN (not of FORSKÅL), Proc. U. S. Nat. Mus., XXV, p. 332; Taihoku, Formosa.—JORDAN & RICHARDSON, Mem. Carneg. Mus., IV, 1909, No. 4, p. 176; Giram, Keelung, Taihoku.—ÔSHIMA, Ann. Carneg. Mus., XII, 1919, Nos. 2–4, p. 270; Formosa.

Head 4.00 in length; depth 4.90; D. IV–1, 8; A. III, 8; P. 16; V. I, 5; width of head 1.50 in its length; eye 4.47; snout 3.24; interorbital space 2.08; first dorsal spine 2.28; first dorsal ray 1.92; third anal spine 3.65; first anal ray 1.92; least depth of caudal peduncle 2.71; thirty-eight scales in a lateral series from gill-opening above to caudal base and three more large ones on the latter; thirteen scales in a

transverse series counted from vent upward and backward to soft dorsal; twenty-two predorsal scales.

Body oblong, elongate, tail very slightly compressed; dorsal profile nearly straight, more or less descending anteriorly, ventral profile strongly curved; head rather small, with depressed top; interorbital space broad, nearly flat; snout short, truncated in front; mouth subinferior, oblique, its angle reaching beyond a vertical through the posterior nostril; cleft of mouth one and half times as broad as deep; mandibular angle obtuse; extremity of maxillary not exposed; lower part of anterior and inferior edges of preorbital denticulated; lower jaw slightly shorter than the upper, outer edge rather sharp, with an inner median keel, which fits into the corresponding concavity on the roof of upper jaw; microscopical teeth on both jaws; upper lip fleshy; lower lip thin, distinct at the angle of mouth only; mandible with two pairs of small open glands beneath; eye large, with well-developed adipose eyelid, which covers part of iris anteriorly and posteriorly; nostrils well separated, the anterior a single pore, the posterior slit-like, in front of eye above.

Scales large, cycloid, outer margin rounded, those on the top of head somewhat larger than others, not reaching to tip of snout; a sharply pointed scaly flap along the base of spinous dorsal; pectoral scaly flap rather short and broad; ventral with a sharply pointed scaly flap at the root; a triangular, broad scaly flap between ventral bases; all the fins, except spinous dorsal, covered with minute scales.

Origin of the spinous dorsal a little nearer to tip of snout than base of caudal, first and second spine subequal in length; soft dorsal inserted slightly nearer to origin of spinous dorsal than base of caudal; origin of anal one scale in advance of that of the soft dorsal, much nearer to caudal base than origin of ventral; pectoral inserted above the middle of body, rather short, not reaching to the spinous dorsal; ventral inserted below the apical one-third of pectoral, not reaching half-way to vent; caudal fin forked.

Color dark gray above, belly and lower part of sides silvery; shining dark stripes along several series of scales; pectorals, dorsals, and caudal dusky, the rest of the fins whitish; a black speck at the base of pectoral.

Total length 600 mm.

Described from a male specimen obtained at the Taihoku Fish

Market on Jan. 22, 1921, preserved in the Museum of the Institute of Science, Formosa. C. M. Cat. of Fishes, No. 8279, Tôkô, Dec. 23, 1920. 360 mm. Coll. M. Ôshima.

Habitat: This is one of the most abundant mullets occurring in the waters of Formosa. Our specimens came from Inzampo, Ritakukan, Tôi, and Tamusui of the State of Taihoku; Kwaren River at Kada, and Botansha, Kwarenko; and from Anpin, Takao, and Tôkô.

Remarks: The present species is so closely allied to *Mugil œur* Forskål of the Indian Ocean that it has been referred to the latter by several authors. It is distinct, however, from *M. œur* in having mandibular bones which meet at an obtuse angle, and thirty-eight or thirty-nine scales in a lateral series instead of forty-two to forty-four (according to the description by Francis Day). Moreover, the depth of this species is much less than that of *Mugil œur,* measuring more than six times in the total length.

Another relative of the present species is *Mugil cephalus* of the Mediterranean. It differs from the common Formosan mullet in having a deeper body and more than forty scales in a lateral series.

We refer this species to *Mugil japonicus* Temminck & Schlegel from Nagasaki, separating the latter from the common Japanese mullet regarded as identical with *Mugil cephalus* Linnæus.

This species is very common on the western coast of Formosa. The season for capturing these fishes commences about the middle of November, when they swarm close ashore along the coast of Shinchiku, coming from the western part of the Formosan channel, probably from Fokien, China. At first they migrate to the south along the western coast of the island and return to the north, after depositing their ova somewhere in the high sea near the southernmost cape. They continue very numerous until about the end of February.

The roes are salted and dried to prepare a special caviar, known as "Karasumi" by the Japanese people.

3. **Mugil anpinensis** Ôshima, sp. nov. (Plate XI, fig. 1.)

Anpin-bora (Japan).

Head 4.16 in length; depth 3.40; D. IV–2, 8; A. III, 9; P. 15; V. I, 5; width of head 1.52 in its length; eye 3.50; snout 3.50; interorbital space 2.25; first dorsal spine 1.44; first dorsal ray 1.68; third anal

spine 2.64; first anal ray 1.68; least depth of caudal peduncle 1.76; twenty-eight scales in a lateral series from gill-opening above to caudal base; ten scales in a transverse series from the vent upward and backward to soft dorsal; sixteen predorsal scales.

Body oblong, rather high, slightly compressed posteriorly; dorsal profile convex, from snout to origin of spinous dorsal nearly straight; head subconic; lower jaw not produced; interorbital space broad, more or less arched; eye anterior, moderate; adipose eyelid well developed, but not covering the iris; mouth subinferior, its angle reaching to a vertical through posterior edge of anterior nostril; mandibular angle obtuse; the cleft of mouth nearly three times as broad as deep; symphysis of the mandibular bones forms a small knob, which fits in a depression of the upper jaw; extremity of maxillary exposed; upper lip fleshy; lower lip thin, with sharp edge; no teeth, except a single row of very small ones along the outer part of the upper jaw; lower preorbital edge minutely serrated; nostrils close together, anterior nostril a simple pore in a very short tube, posterior nostril slit-like; isthmus narrow, elongate, somewhat constricted at middle.

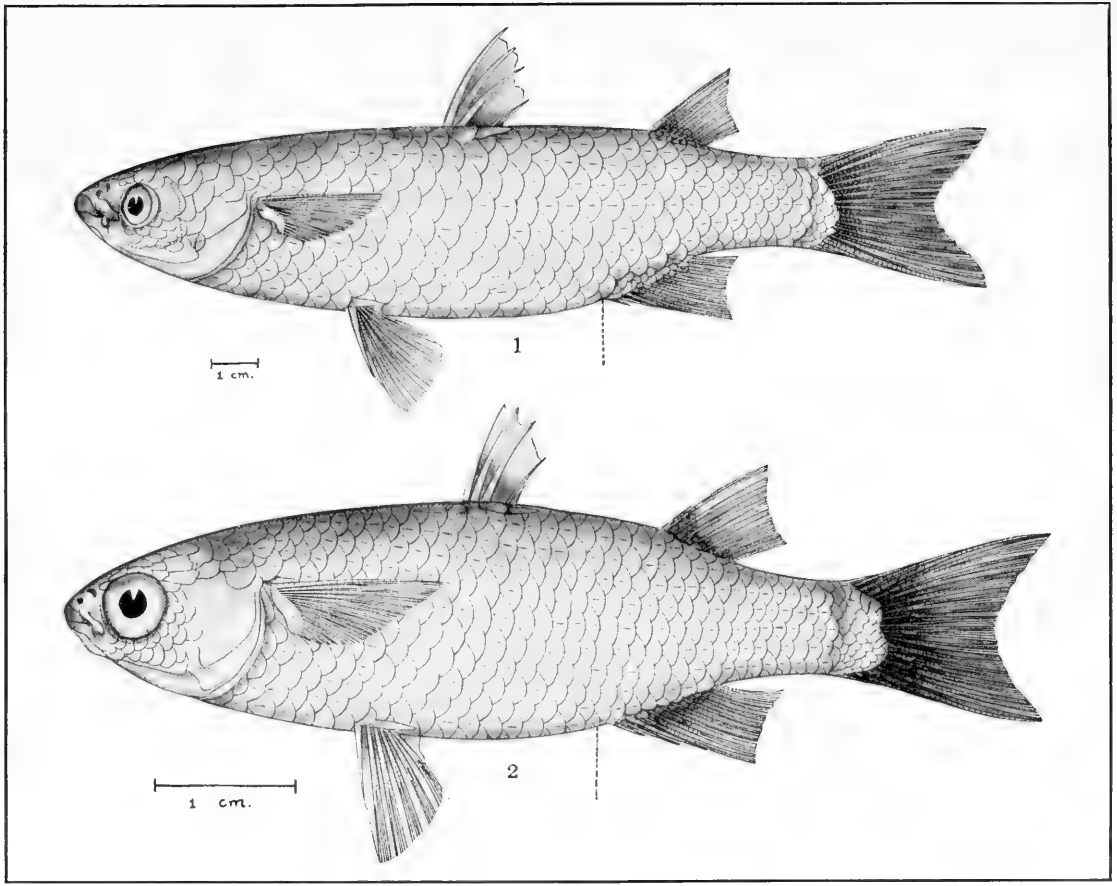
Scales large, round; head scaly, small scales below, larger scales extend forward on snout though not quite to its edge; a sharply pointed scaly flap along the spinous dorsal base; pectoral with no scaly flap; ventral with a sharply pointed scaly flap at the root; a broad scaly flap between ventral bases; soft dorsal, anal, and caudal covered with small scales.

Origin of spinous dorsal midway between tip of snout and base of caudal, first and second spine subequal; soft dorsal inserted nearer base of caudal than origin of spinous dorsal; origin of anal two and one-half scales in advance of that of soft dorsal, nearer to caudal base than the origin of ventral; pectoral rather short, reaching more than half-way to spinous dorsal, inserted in the middle of body above; ventral inserted below the last one-third of the pectoral, not reaching midway to vent.

Color in life bluish gray above, silvery, undersides whitish; spinous dorsal dusky; soft dorsal and caudal finely dusted with dark specks, edge of the latter darker; ventral and anal fins whitish; a dark line along each row of scales on upper three-fourths of body.

Total length 188 mm.

Type: Described from a specimen from Anpin, collected by M.



1. *Mugil anpinensis* Oshima, sp. nov.
2. *Liza parva* Oshima, sp. nov.

Watanabe. In Carnegie Museum. C. M. Cat. of Fishes, No. 8281. Labeled "Type Specimen." Coll. M. Ôshima.

Habitat: Anpin near Tainan (two specimens); Kwaren River at Kada, Kwarenkô (three specimens).

Remarks: The present species is closely related to *Mugil argenteus* from South Australia, differing from it in having the extremity of the maxillary extremity exposed; sixteen predorsal scales; the spinous dorsal inserted midway between tip of snout and caudal base.

The figure is taken from a specimen from the Kwaren River, which measured 196 mm. in total length.

4. **Mugil carinatus** (Ehrenberg) Cuvier & Valenciennes.
Sesuji-bora (Japan); Tawah (Formosa).

1830. *Mugil carinatus* (EHRENBERG) CUVIER & VALENCIENNES, Hist. Nat. Poiss., XI, p. 148; Red Sea.—DAY, Fish. Brit. India, 1888, Suppl., p. 800; Seas of India.—ÔSHIMA, Ann. Carneg. Mus., XII, 1919, Nos. 2–4, p. 272; Shimo-Tamusui River; Taihoku.

Head 4.01 in length, depth 4.51; D. IV–2, 7; A. III, 9; P. 15; V. I, 5; width of head 1.70 in its length; eye 4.50; interorbital space 2.73; snout 4.00; first dorsal spine 2.18; first dorsal ray 2.00; third anal spine 4.28; first anal ray 2.18; least depth of caudal peduncle 2.18; thirty-eight scales in a lateral series from gill-opening above to caudal base, three more larger ones on the latter; eleven scales in a transverse series from the vent upward and backward to soft dorsal; twenty-eight predorsal scales.

Body oblong, elongate, slightly compressed posteriorly; curvature of dorsal profile weaker than that of the ventral; median dorsal line keeled in front of and behind the spinous dorsal; head subconiform, pointed anteriorly, its top more or less convex; snout narrow and pointed; interorbital space slightly convex; mouth subinferior, nearly horizontal, its angle reaching a vertical through the posterior nostril; cleft of mouth more than two times as broad as deep; mandibular angle obtuse, two small pores on either side beneath; upper jaw protruding beyond the lower; upper lip thick, fleshy; lower lip thin, with sharp edge; symphysis of the mandibular bones forming a small knob, which fits into a depression on the roof of the upper jaw; extremity of maxillary exposed; lower end of pre-orbital finely serrated; no teeth, except a series of microscopical ones along the outer edge of

upper lip; eye large, anterior, with a broad posterior adipose eyelid, nearly reaching the iris; nostrils separated, anterior nostril a single pore in a short tube, posterior nostril slit-like, in front of eye above.

Spinous dorsal inserted much nearer tip of snout than base of caudal, first and second spine subequal in length; soft dorsal inserted midway between origin of spinous dorsal and caudal base, rather short; origin of anal a little in advance of that of the soft dorsal, nearer to caudal base than origin of ventral; pectoral inserted above the middle of body, not extending to the origin of spinous dorsal; ventral inserted below apical one-fifth of the pectoral, not reaching midway to vent; caudal fin forked.

Head and body covered with uniform cycloid scales, outer edge of each scale obtusely pointed; a sharply pointed scaly flap along the spinous dorsal base; pectoral with no scaly flap; ventral fin provided with a sharply pointed scaly flap; a broad scaly flap between ventral bases; soft dorsal, anal, pectoral, and base of caudal covered with minute scales.

Color in life dusky gray above, lower parts whitish, silvery, with no longitudinal stripes along the series of scales; center of each scale somewhat darker; pectorals, dorsals, and caudal dusky; the rest of the fins whitish.

Total length 303 mm.

Described from a specimen from Tainan Fish Market, collected by M. Ôshima on April 20, 1920, and now in the Carnegie Museum. C. M. Cat. of Fishes, No. 8280. (Coll. M. Ôshima.)

Habitat: Many specimens from Tainan Fish Market and Ujuon near Tôkô; a single specimen from Shimo-Tamusui River, and two from Taihoku Fish Market.

Remarks: One of the commonest species of mullets found in Formosa, never reaching a large size.

5. MUGIL KELAARTII Günther.

Nanyo-bora (Japan).

1861. *Mugil kelaartii* GÜNTHER, Cat. Fish. Brit. Mus., III, p. 429; Point de Galle, P. I.—PETERS, Monatsb. Königl. Akad. Wiss. Berlin, 1868, p. 263; Luzon.—FOWLER, Proc. Acad. Nat. Sci. Phila., 1900, p. 500; Sandwich Is. —Proc. Acad. Nat. Sci. Phila., 1903, p. 743; Hawaiian Islands.

Head 4. in length; depth 3.62; D. IV–1, 8; A. III, 9; P. 15; width

of head 1.57 in its length; eye 3.50; snout 4.; interorbital space 2.32; first dorsal spine 2.25; first dorsal ray 1.68; third anal spine 2.47; first dorsal ray 1.64; least depth of caudal peduncle 2.; thirty-three scales in a lateral series from gill-opening above to caudal base; eleven scales counted from the vent upward and backward to soft dorsal; nineteen predorsal scales.

Body compressed, the upper profile weakly curved, gradually descending anteriorly, the curvature of the lower profile stronger than the former; head subconic; interorbital space convex; snout rather short, convex, with a somewhat sharp edge; eye anterior, moderate; adipose eyelid thin, not covering the iris, the posterior lid broader than the anterior; mouth subinferior, slightly oblique, its angle reaching to a vertical through the posterior nostril; upper lip situated obliquely at the lower edge of the snout, rather thin; both jaws with no teeth, edge of the lower thin and sharp; mandibular angle obtuse; the cleft of the mouth two and one-half times as broad as deep; extremity of the maxillary entirely hidden by the pre-orbital, inferior edge of the latter denticulated; isthmus remarkably narrow, distinct only at the middle of the lower jaw; nostrils separated, the posterior larger than the anterior, slit-like, situated in front of eye above.

Scales cycloid, outer margin rounded, with a shallow longitudinal groove; those on the top of head larger and irregular, not extending to the tip of snout; a sharply pointed scaly flap along the base of spinous dorsal, extending backward beyond the base of the fin; pectoral and ventral with a scaly flap; a broad scaly flap between the ventral bases; soft dorsal, anal, and caudal covered with small scales.

Origin of the spinous dorsal midway between the tip of snout and caudal base, first and second spines subequal in length; soft dorsal inserted midway between origin of spinous dorsal and the base of caudal; origin of the anal in advance of that of the soft dorsal, root of the fourth ray corresponds to the origin of the latter; pectoral nearly as long as the head, reaching to the origin of spinous dorsal; ventral inserted below the middle of pectoral, reaching more than half the distance to the vent; caudal forked, tip of each lobe sharply pointed.

Color in alcohol bluish gray above and shining silvery below, with no stripes; a black marking at the root of pectoral; dorsals and caudal dusky, the rest of the fins whitish.

Total length 185 mm.

Described from a specimen from Tôkô, collected by M. Ôshima on Dec. 23, 1920, and preserved in the Museum of the Institute of Science, Formosa. C. M., Cat. of Fishes, No. 8282. 182 mm. Dec. 20, 1920. (Coll. M. Ôshima.)

Habitat: Two specimens from Tôkô.

Remarks: Both specimens from Tôkô are identical with Günther's *M. kelaartii.* An Indian mullet described by Francis Day under the name *M. kelaartii* (Fishes of India, p. 352) differs from the type in having the extremity of the maxillary exposed.

2. Genus LIZA Jordan & Swain.

1884. *Liza* JORDAN & SWAIN, Proc. U. S. Nat. Mus., VII, p. 261. (Type *Mugil capito* Cuvier.)

Body robust, more or less oblong and compressed. Head and body covered with large scales. Mouth subinferior, more or less transverse; upper lip not much enlarged; teeth movable, ciliiform, sometimes obsolete; anterior margin of mandible thin and sharp. Eyes without adipose eyelid. First dorsal consisting of four stiff spines; anal opposite the soft dorsal, slightly longer than the latter, with three spines. This genus differs from *Mugil* mainly in the absence of the adipose eyelid.

Distribution: British and Scandinavian coast; Canary Islands; Mediterranean; Nile; fresh-water lakes of Tunis; from Red Sea through Indian Ocean and Archipelago to the coasts of Australia and Polynesia; India; Ceylon; Philippine Islands; Indo-China; Formosa; Riu Kiu Islands; Japan.

KEY TO FORMOSAN SPECIES OF LIZA.

a^1. The upper lip not notably thickened.

b^1. 39–40 scales in a lateral series; extremity of maxillary not exposed. *formosæ,* 6.

b^2. 30–33 scales in a lateral series.

c^1. Extremity of maxillary not exposed; nostrils separated; origin of spinous dorsal a little nearer to caudal base than tip of snout. *parva,* 7.

c^2. Extremity of maxillary exposed; nostrils close together.

d^1. Mandibular angle obtuse; the cleft of mouth three and one-half times as broad as deep; origin of spinous dorsal midway between tip of snout and base of caudal.... *pescadorensis,* 8.

d^2. Mandibular angle obtuse; the cleft of mouth three times as broad as deep; origin of spinous dorsal nearer to base of caudal than tip of snout.....*troscheli*, 9.

6. **Liza formosæ** Ôshima, sp. nov. (Plate XII, fig. 2.)

Taiwan-menada (Japan).

1865. *Mugil suppositus* DAY, Fishes of Malabar, p. 143; Seas of Malabar and Malaysia; Cochin (not of GÜNTHER).

Head 3.64 in length; depth 3.33; D. IV–2, 7; A. III, 9; P. 16; V. I, 5; width of head 1.50 in its length; snout 3.37; interorbital space 2; eye 4.28; first dorsal spine 2.23; first dorsal ray 1.64; third anal spine 3.50; first anal ray 1.75; least depth of caudal peduncle 2.23; forty scales (thirty-nine scales on the right) in a lateral series from gill-opening above to caudal base, three more scales on the latter; thirteen scales in a transverse series from the vent upward and backward to soft dorsal; about twenty predorsal scales.

Body oblong, rather high, slightly compressed posteriorly; dorsal and ventral profiles equally convex; head broad, rounded anteriorly; a slight ridge from the upper surface of orbit to the pectoral base; interorbital space more or less convex, rather broad; snout short, not truncated in front; mouth subinferior, transverse, the cleft four times as broad as deep, its angle reaching a vertical through the posterior nostril; mandibular angle markedly obtuse; upper jaw rounded, a little longer than the lower, with a depression in its inner center, receiving a knob on the lower jaw; upper lip fleshy, lower lip thin, distinct only at the angle of mouth; isthmus extremely narrow, elongate; no teeth in the lips; extremity of maxillary entirely hidden; both the anterior and lower edges of pre-orbital denticulated; eye rather small, anterior, with no adipose eyelid; nostrils separated, anterior nostril a single pore in a short tube, posterior nostril slit-like, midway between the former and orbit above.

Head and body covered with uniform cycloid scales, those on the top of head somewhat larger and irregular; outer margin of each scale rounded; a fine longitudinal groove on all the scales, except those on head; a scaly flap along the base of spinous dorsal sharply pointed, elongate, extending backward beyond the base of the fin; pectoral and ventral with a sharply pointed scaly flap; a broad scaly

flap between ventral bases; basal part of pectoral, soft dorsal, anal, and caudal fins covered with minute scales.

Origin of spinous dorsal midway between tip of snout and base of caudal, rather tiny, its first three spines subequal in length, inserted close together, the third somewhat shorter, the fourth spine much weaker and shorter; soft dorsal inserted much nearer to spinous dorsal than base of caudal, the distance between two dorsals equal the length of anterior margin of soft dorsal; anal slightly in advance of the origin of soft dorsal, third spine half as long as the first ray, the last ray divided into two; upper margin of pectoral in the upper third of body, shorter than the head, scarcely reaching the origin of spinous dorsal; ventrals rather short, extending midway to vent; caudal fin forked in its posterior third.

Color in alcohol dusky gray above, whitish and silvery below; body with longitudinal stripes along the series of scales; first and second dorsals, caudal, anal, and pectoral yellowish, minutely dotted with black; ventral whitish; a black speck superiorly at the base of pectoral.

Total length 126 mm.

Type: Described from a single specimen from Anpin, collected by M. Watanabe on Nov. 6, 1919, and preserved in the Carnegie Museum, Cat. of Fishes, No. 8283. 126 mm. (M. Watanabe, Coll.)

Habitat: Anpin near Tainan.

Remarks: In the year 1865 Francis Day described a small mullet from the Seas of Malabar under the name *Mugil suppositus* in his paper entitled "The Fishes of Malabar." It is quite different, however, from Günther's *M. suppositus,* because the latter is provided with eight anal rays, the last of which is split to its base, while the form under consideration has nine soft rays, the last of which is distinctly divided into two at the base.

The present species is identical with Day's *M. suppositus,* distinctly differing from the form so named by Günther in having the maxillary entirely covered by the pre-orbital and nine soft dorsal rays. It is necessary, therefore, to give a new name to it, Day's *M. suppositus* being regarded as identical.

7. **Liza parva** Oshima, sp. nov. (Plate XI, fig. 2.)
Hime-menada (Japan); Shoahii (Formosa).

Head 3.73 in length; depth 3.35; D. IV–1, 8; A. III, 9; P. 15; V. I, 5; width of head 1.78 in its length; snout 3.75; eye 3.20; interorbital space 2.67; first dorsal spine 1.78; first dorsal ray 1.60; third anal spine 2.50; first anal ray 1.67; least depth of caudal peduncle 2.29; pectoral 1.14; ventral 1.50; thirty-three scales in a lateral series from gill-opening above to caudal base and three more large ones on the latter; eleven scales from the vent upward and backward to the soft dorsal; eighteen predorsal scales.

Body rather high, strongly compressed, deepest at the origin of spinous dorsal; dorsal profile convex, gradually descending anteriorly, ventral profile much more convex than the former; head small, subconiform; snout short, rather broad, truncated in front; interorbital space more or less convex; eye moderate, anterior, with no adipose eyelid; mouth subinferior, its angle reaching a vertical through anterior border of posterior nostril, the cleft three times as broad as deep; mandibular angle obtuse, symphysis forming a small knob, which fits into a depression above; extremity of maxillary entirely hidden; teeth none on both jaws; upper lip fleshy; lower lip thin, with sharp edge; lower pre-orbital edge finely serrated; nostrils separated, the anterior a simple pore, nearer to extremity of snout than orbit, the posterior slightly larger than the former, semilunar, with a cutaneous membrane, situated midway between anterior nostril and orbit above; isthmus elongate, lanceolate, slightly constricted at middle.

Scales in an even longitudinal series, rather thin, round; head scaly, smaller scales below, extending forward on snout though not quite to its edge; a sharply pointed scaly flap along the spinous dorsal base; pectoral with a short scaly flap; a slender pointed scaly flap at the root of ventral; a broad scaly flap between ventral bases; base of the soft dorsal, anal, and caudal covered with small scales.

Origin of the spinous dorsal a little nearer base of caudal than tip of snout, first and second spines subequal in length; soft dorsal inserted nearer origin of spinous dorsal than the base of caudal; origin of anal two scales in advance of that of the soft dorsal, midway between caudal base and origin of ventral; pectoral elongate, scarcely reaching to the origin of spinous dorsal, inserted in the middle of body

above; ventral inserted below the middle of pectoral, reaching beyond midway to vent.

Color in alcohol slaty above, lower part silvery; spines and rays of dorsal fins minutely speckled with black, the fin-membranes whitish; caudal fin more or less dusky, with darker edge; pectoral, ventral, and anal fins whitish.

Total length 70 mm.

Type: Described from a specimen from Anpin, collected by M. Watanabe, and preserved in the Carnegie Museum, Cat. of Fishes, No. 8284. 70 mm.

Habitat: Six specimens were obtained at Anpin near Tainan, all mature, with ripened ovaries and testes; and numerous examples from Tôkô at the estuary of the Shimo-Tamusui River.

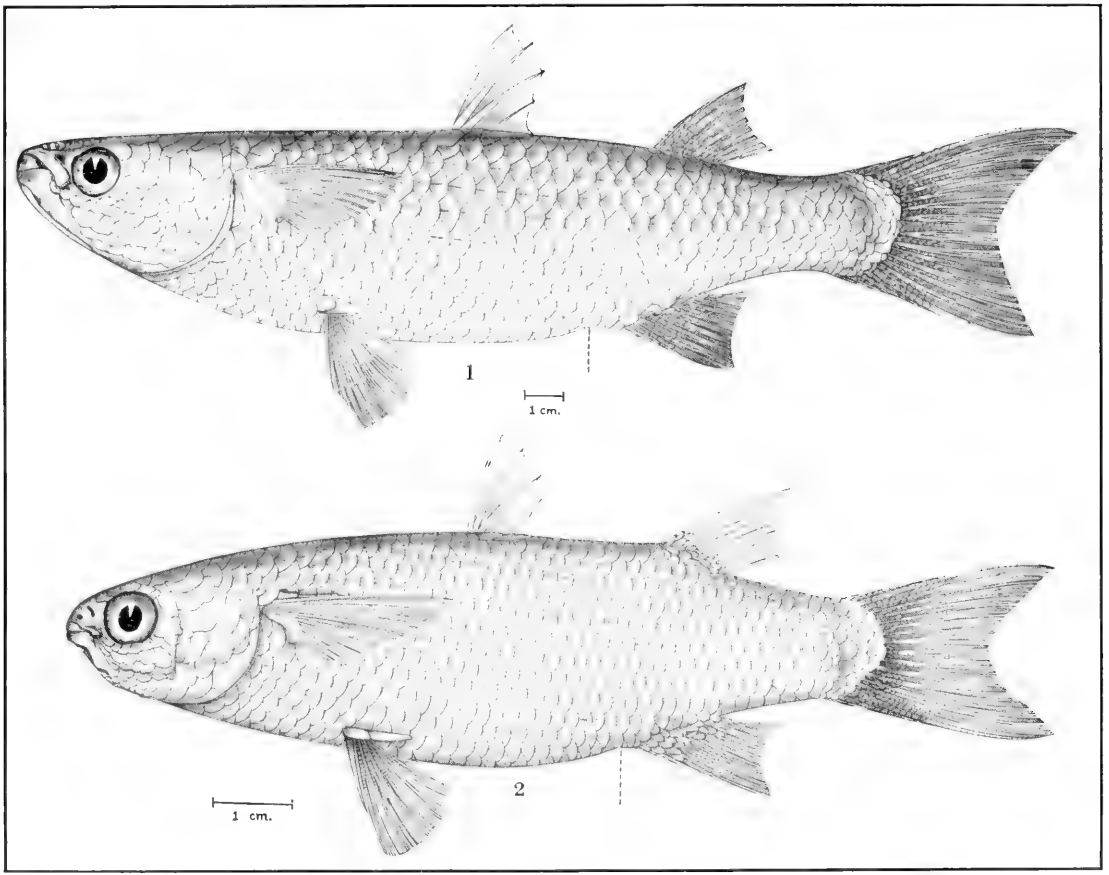
Remarks: The present species is closely allied to *Liza troscheli,* differing from it, however, in having the maxillaries not exposed and the nostrils separated.

8. **Liza pescadorensis** Ôshima, sp. nov. (Plate XII, fig. 1.)

Taiwan-bora (Japan).

Head 3.96 in length; depth 4.11; D. IV–1, 8; A. III, 9; P. 16; V. I, 5; width of head 1.44 in its length; snout 3.59; eye 4.38; interorbital space 2.20; first dorsal spine 1.65; first dorsal ray 1.93; third anal spine 3.; first anal ray 2.28; least depth of caudal peduncle 2.33; pectoral 1.40; ventral 1.75; thirty-three scales in a lateral series from gill-opening above to caudal base and four more large ones on the latter; ten scales in a transverse series from the vent upward and backward to soft dorsal; twenty predorsal scales.

Body elongate, compressed posteriorly; dorsal profile nearly straight, very slightly descending anteriorly, ventral profile convex; deepest at the origin of spinous dorsal; head rather robust, lower surface more or less constricted below eye; lower surface much more inclined than the superior; snout quadrate, rather broad; interorbital space flattened, nearly straight; eye large, anterior, with no adipose eyelid; mouth subinferior, the cleft three and one-half times as broad as deep, its angle scarcely reaching a vertical through the anterior border of the anterior nostril; mandibular angle remarkably obtuse, symphysis forming a small knob, which fits into a depression above; ex-



1. *Liza pescadorensis* Oshima, sp. nov.
2. *Liza formosæ* Oshima, sp. nov.

tremity of maxillary exposed; teeth none, except a single series of minute ones along the extremity of upper lip; upper lip rather fleshy; lower pre-orbital edge finely denticulate; isthmus narrow, elongate, slightly constricted at middle, lanceolate; nostrils close together, anterior nostril a simple pore with slight cutaneous rim; posterior nostril much larger than the former, widely opened.

Scales moderate, in an even longitudinal series, mostly uniform; head scaly, smaller scales below, large scales extend forward on snout, though not quite to its edge; a scaly pointed flap along the spinous dorsal base; pectoral fin with no scaly flap; axillary scaly ventral flap two in the fin, sharply pointed; a broad scaly flap between ventral bases; soft dorsal, anal, and caudal covered with minute scales.

Origin of spinous dorsal midway between tip of snout and base of caudal, first and second spine subequal in length; soft dorsal inserted midway between origin of spinous dorsal and base of caudal; origin of anal two scales before that of the soft dorsal, much nearer caudal base than the ventral origin; caudal fin deeply forked, upper lobe somewhat longer than the lower; pectoral rather short, inserted above the middle of the body; ventral inserted about opposite last third in pectoral, not reaching half way to vent.

Color in alcohol bluish gray above, whitish below, silvery; spinous dorsal dusky; soft dorsal, anal, and caudal uniformly dusted with dusky specks, edge of the latter somewhat darker; pectoral more or less dusky; ventral whitish; body with no distinct dark stripes along each row of scales.

Total length 275 mm.

Type: Described from a specimen from Bakô, Pescadores Islands, collected by M. Ôshima on June 5, 1920, and now in the Carnegie Museum, Cat. of Fishes, No. 8285.

Habitat: Our specimens came from Pescadores Islands and Tôkô, a small town in the southernmost part of Formosa.

Remarks: The present species is very closely allied to *Liza smithi* from the Cape of Good Hope, differing from it in having ten scales in a transverse series instead of eleven to twelve.

9. **Liza troscheli** (Bleeker).

Kobora (Japan).

1858. *Mugil troscheli* BLEEKER, Nat. Tijdschs. Ned. Ind., XVI, p. 277.—Act. Soc. Sc. Indo-Neerl., VIII, 1860, p. 80; Sumatra.—GÜNTHER, Cat. Fish., III, 1861, p. 448; Coast of Java, Borneo, and Ceylon.—DAY, Fish. Brit. India, 1878, p. 358; Indian Sea to Malay Archipelago.—RUTTER, Proc. Acad. Nat. Sci. Phila., 1897, p. 70; Swatow.

1903. *Liza troscheli* JORDAN & EVERMANN, Proc. U. S. Nat. Mus., XXV, p. 332; Hôkotô, Formosa.—JORDAN & SEALE, Bull. U. S. Bur. Fish., XXVI, 1906, p. 11; Cavite, P. I.—JORDAN & RICHARDSON, Bull. U. S. Bur. Fish., XXVII, 1908, p. 244; Iloilo.—SMITH & SEALE, Proc. Biol. Soc. Wash., XIX, p. 76; Mindanao.—SEALE & BEAN, Proc. U. S. Nat. Mus., XXXIII, 1907, p. 240; Zamboanga.—JORDAN & RICHARDSON, Mem. Carneg. Mus., IV, No. 4, 1909, p. 176; Takao; Hôkotô, Formosa.—SNYDER, Proc. U. S. Nat. Mus., XXXII, 1912, p. 495; Okinawa.—JORDAN & STARKS, Ann. Carneg. Mus., XI, Nos. 3 & 4; 1917, p. 439; Ceylon.—ÔSHIMA, Ann. Carneg. Mus. XII, 1919, Nos. 2–4; Sobun R.; Hôkotô; Takao, Formosa.

Head 4 in length; depth 4.06; D. IV–2, 7; A. III, 9; P. 15; V. I, 5; width of head 1.31 in its length; eye 4; snout 3.42; interorbital space 2.27; first dorsal spine 1.79; first dorsal ray 2.; third anal spine 3.33; first anal ray 1.79; thirty-two scales in a lateral series from gill-opening above to caudal base, and three more large ones on the latter; ten scales in a transverse series from the vent upward and backward to soft dorsal; about twenty predorsal scales.

Body oblong, compressed posteriorly, the ventral profile much more curved than the dorsal, the profile between tip of snout and spinous dorsal slightly convex, gradually descending anteriorly; deepest at the origin of spinous dorsal; head rather small, top more or less convex; snout quadrate, truncated in front; interorbital space rather broad, slightly convex; upper jaw longer than the lower; mouth subinferior, slightly oblique, its angle reaching a vertical through the posterior border of the anterior nostril; the cleft three times as broad as deep; mandibular angle obtuse; extremity of maxillary exposed; upper lip fleshy, with a series of minute teeth along the outer edge; lower jaw with no teeth, its outer edge thin and sharp; a depression in the upper jaw receiving a small knob on the symphysis of the lower jaw; lower external edge of the pre-orbital finely denticulated; isthmus very narrow, elongate; eye moderate, with no adipose eyelid; nostrils close together, the anterior a simple pore in a very short tube, the posterior slit-like, a little larger.

Origin of spinous dorsal nearer to base of caudal than tip of snout, anterior three spines inserted close together, the first and second subequal in length; soft dorsal inserted nearer base of caudal than origin of anal; origin of anal three scales in advance of that of the soft dorsal, much nearer to base of caudal than origin of ventral; pectoral inserted above the middle of body, rather short, not reaching the spinous dorsal; origin of ventral below the last third of the pectoral, not reaching half way to vent; caudal fin forked at the apical one-third.

Head and body covered with large cycloid scales, outer edge of each scale obtusely pointed; scales on the top of the head somewhat larger and irregular, not reaching the tip of snout; a sharply pointed scaly flap along the base of spinous dorsal; pectoral with no scaly flap; ventral with a sharply pointed scaly flap, a broad scaly flap between ventral bases; soft dorsal, anal, basal part of pectoral, and caudal covered with small scales.

Color in alcohol dusky gray above, lower parts white, silvery; ventrals whitish; the rest of the fins dusky.

Total length 257 mm.

Described from a specimen from Bakô, Pescadores Islands, collected by Ôshima on June 2, 1920, and now in the Carnegie Museum, Cat. of Fishes, No. 8286. 257 mm.

Habitat: Our specimens came from Sobun River near Tabani; Tôkô; Takao; Buraku River; Akô; and Pescadores Islands. One of the commonest mullets in Formosa.

Genus CHELON Röse.

1793. *Chelon* RÖSE, Petri Artedi Angermannia Sueci Synonymia Nominum Piscium, Editio II, p. 118. Type χελών Aristotle, *Mugil chelo* Cuvier and Valenciennes.

1863. *Chænomugil* GILL., Proc. Acad. Nat. Sci. Phila., XV, p. 169. Type *Mugil proboscideus* Günther.

This genus, as here understood, agrees with *Liza* in the absence of the adipose eyelid, differing, however, in the greatly thickened upper lip, which, in typical species, at least, is fringed on the edge and covered with flat, flexible teeth. Further comparative studies are necessary before we can be sure that *Chænomugil* is identical with *Chelon*, and the Formosan species may be generically distinct from both.

10. **Chelon crenilabis** (Forskål). (Plate XIII, fig. 1.)

Boko-menada (Japan).

1775. *Mugil crenilabis* FORSKÅL, Descr. Anim., p. 73.—CUVIER & VALENCIENNES, Hist. Nat. Poiss., XI, 1828, p. 123.—GÜNTHER, Cat. Fish. Brit. Mus., III, 1861, p. 458; Red Sea.

1828. *Mugil fasciatus* CUVIER & VALENCIENNES, Hist. Nat. Poiss., XI, p. 125.

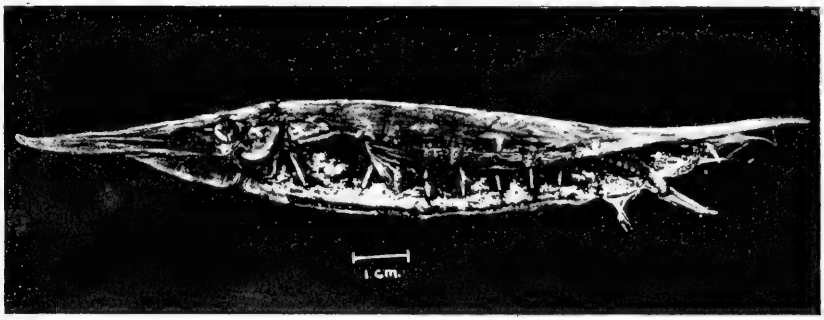
Head 4. in length; depth 3.53; D. IV–2, 7; A. III, 9; P. 16; V. I, 5; width of head 1.46 in its length; snout 2.83; interorbital space 2; eye 4.52; first dorsal spine 2.; first dorsal ray 1.64; third anal spine 3.; first anal ray 1.53; least depth of caudal peduncle 1.92; forty scales in a lateral series from gill-opening above to caudal base, three more large scales on the latter; twelve scales in a transverse series from vent upward and backward to the soft dorsal; about twenty-one predorsal scales.

Body oblong, rather high, slightly compressed posteriorly; dorsal and ventral profiles equally convex; head subconiform, upper surface more or less convex; interorbital space rather broad; snout short, truncated in front; mouth terminal, transverse, the cleft four times as broad as deep, its angle reaching to a vertical through the posterior nostril; mandibular angle obtuse; upper lip remarkably thick, granulated, with small fleshy fringes along its edge, inferior part whitish; lower lip rather thin, outer edge fringed; depression of the upper jaw shallow, receiving a small knob at the symphysis of the lower jaw; extremity of maxillary entirely hidden by pre-orbital, inferior edge of the latter denticulated; isthmus very narrow, elongate; eye moderate, anterior, with no adipose eyelid; nostrils separated, the posterior slit-like, situated midway between the anterior nostril and orbit above.

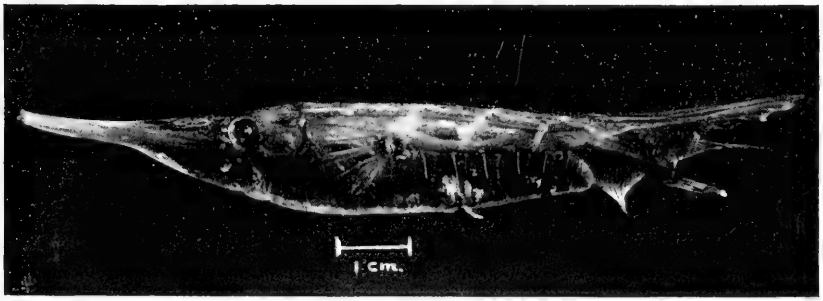
Head and body covered with uniform cycloid scales, those on the top of head somewhat larger and irregular; a fine longitudinal groove on the scales on the body; a sharply pointed scaly flap along the base of spinous dorsal, extending backward beyond the base of the fin; pectoral and ventral with a pointed scaly flap; a broad scaly flap between ventral bases; soft dorsal and anal scaly; proximal part of the caudal covered with small scales.

Origin of spinous dorsal nearer tip of snout than caudal base, first spine the longest, fourth spine rather tiny; soft dorsal inserted much

1



2



3

1. *Chelon crenilabis* (Forskål).
2. *Centriscus scutatus* Linnæus.
3. *Centriscus capito* Oshima, sp. nov.

nearer to the spinous dorsal than caudal base, the distance between two dorsals much longer than the length of anterior margin of soft dorsal; anal inserted slightly in advance of the origin of soft dorsal, third spine nearly half as long as the first ray; pectoral inserted in the middle of the body above, not reaching the origin of spinous dorsal; ventrals rather short, extending beyond half-way to vent; caudal fin forked, tip of each lobe sharply pointed.

Color in alcohol uniformly dusky gray above, whitish and silvery below; upper two-thirds of the upper lip gray; a black spot superiorly at the base of pectoral; all the fins except ventrals dusky.

Total length 258 mm.

Described from a specimen from Pescadores Islands, collected by M. Ôshima on September 15, 1920. [This example seems to agree fully with the account of *Mugil crenilabis* as given by Cuvier and Valenciennes. It is not, however, a true *Mugil*, and it may prove the type of a genus distinct from *Chelon*.—D. S. JORDAN.]

Habitat: Pescadores Islands[1] (a single specimen).

[1] The "Pescadores Islands" here mentioned, are a small group west of Formosa, and not to be confounded with other groups of the same name.—ED.

VII. A REVIEW OF THE FISHES OF THE FAMILY CENTRISCIDÆ FOUND IN THE WATERS OF FORMOSA.

By Masamitsu Ôshima, Ph.D.

(Pl. XIII, figs. 2–3.)

The present paper gives a review of the fishes of the family *Centriscidæ* found in the waters of the Island of Formosa. It is based on the material in the Institute of Science of the Government of Formosa, collected by Mr. Muneshige Watanabe of the Marine Experiment Station at Tainan, and Mr. Akitaro Kihara of the Tôkô Fish Market. I express my hearty thanks for the courtesy shown by those two gentlemen.

Family CENTRISCIDÆ.

(The Shrimp Fishes.)

Form of body elongate, much compressed. Anterior bones of skull much produced and forming a long tube terminating in a small mouth. Body covered with a bony dorsal cuirass, which is connate with the internal skeleton, ending posteriorly in a long projection, which has sometimes a movable spine at its end. Longitudinal axis of the tail deflected from that of the trunk through the encroachment of the dorsal cuirass. Dorsal fins two, crowded together under the terminal spine of dorsal cuirass. Ventrals abdominal. Teeth none. Parietals absent. Post-temporal suturally connected to cranium; supraclavicle present. Ribs developed. Postclavicles present.

Habitat: Indian Ocean to Western Pacific.

Species few and small, fantastically formed, the translucent carapace suggesting that of a shrimp (Jordan & Starks).

1. Centriscus Linnæus.

1758. *Centriscus* Linnæus, Syst. Nat., Ed. X, Vol. I, p. 336. (Type *Centriscus scutatus* Linnæus.)

1775. *Amphisilen* Klein, Neu. Schauplatz Nat. I, p. 280. (Type *Centriscus scutatus* Linnæus) (non-binomial).

1817. *Amphisile* (Klein) Cuvier, Règne Anim., Ed. I. (Type *Centriscus scutatus* Linnæus.)

Body elongate, strongly compressed, provided with a dorsal cuirass which is formed by portions of the skeleton; the longitudinal axis of the tail is not in the plane with that of the trunk. Scales none. Two dorsal fins, situated on the hindermost part of the back; ventral fins rudimentary, abdominal. Three or four branchiostegals; gill-opening of moderate width, four gills and pseudobranchiæ; air-bladder large; pyloric appendage none.

Distribution: From the eastern coast of Africa to the seas of China.

KEY TO SPECIES FOUND IN FORMOSA.

a^1. Length of head three or more than three in the total length; ventrals with three rays inserted midway between the anterior border of orbit and the last anal ray; the distance between the pectoral and the tip of snout equal to that between the former and the root of the first dorsal spine.

scutatus, 1.

a^2. Length of head less than three in the total length; ventrals with four rays inserted behind the midway between the anterior border of orbit and last anal ray; the distance between the pectoral and the tip of snout much longer than that between the former and the root of the first dorsal spine.

capito, 2.

1. **Centriscus scutatus** Linnæus. (Plate XIII, fig. 2.)

Yoroi-uwo (Japan) (Armour-fish).

1758. *Centriscus scutatus* LINNÆUS, Syst. Nat., Ed. X, p. 415.—GMELIN, Car. Linn. Syst. Nat., 1778, p. 1460.—BLOCH, Naturg. ausl. Fisch., 1786, IV, p. 80, Pl. 123, fig. 2; India.—LACÉPÈDE, Hist. Nat. Poiss., II, 1798, p. 88, i, Pl. XIX, fig. 2.—BLOCH & SCHNEIDER, Syst. Ichth., 1801, p. 113.—SHAW, Gen. Zool., V, 1800, p. 458, pl. 181.—BLEEKER, Versl. Akad. Amst. (2) II, 1868, p. 298; Waigiou.—Fish. Madagascar, 1875, p. 75; Madagascar.—JORDAN & SEALE, Bull. Bur. Fish., XXVI, 1906, p. 9; Manila.—WEBER, Fisch Siboga Exped., 1913, p. 99; Lombock; Banda; Timor.

1763. *Centriscus* sp. GRONOVIUS, Zoophyl., No. 396, tab. 7, fig. 3.

1817. *Amphisile scutata* CUVIER, Règne Anim., Guér. Iconogr. Poiss., pl. 45, fig. 3.—BLEEKER, Journ. Ind. Arch. II, 1848, No. 9, p. 633; Sumbawa.—JERDON, Mad. Journ. Linn. Sc., XVII, 1851, p. 140; Madras.—BLEEKER, Nat. Tijdschr. Ned. Ind., II, 1851, p. 245; Banda.—*l. c.* III, 1852, p. 235; Amboina; Ceram.—*l. c.* XII, 1856, p. 216; Nias.—*l. c.* XII, 1856, p. 234; Batae Is.—*l. c.* XIII, 1857, p. 372; Sangi Is.—*l. c.* XV, 1858, p. 202; Goram Arch.—*l. c.* XVIII, 1859, p. 373; Banka.—Act. Soc. Sc. Indo-Neerl., VIII, 1860, p. 63.—GÜNTHER, Cat. Fish., III, 1861, p. 525; East Indian and Chinese Seas.—BLEEKER, Act. Soc. Ind. Neerl., VIII, 1860, p. 15; Celebes.—Versl. Akad. Amst., XII, 1861, p. 41; Singapore.—*l. c.* XIV, 1862, p. 103;

Batan.—Ned. Tijdschr. Dierk., I, 1863, p. 154; Haemahera.—*l. c.* I, 1863, p. 275; Timor.—*l. c.* IV, 1873, p. 133; China.—LÜTKEN, Vid. Medd. Nath. Fören, Kjøb., 1865, p. 213.—KLUNZIGER, Verh. z. b. Ges. Wien. 1871, p. 517.—DAY, Fish. India, 1878, p. 361; Seas of India to China.—GÜNTHER, Rept. Shore Fish., 1880, p. 53; Philippines.

Head 3. in the total length; depth 7.63; width of head 9.80 in its length; interorbital space 11. in head; eye 11.; 1.60 in postorbital part; D. III, 10; A. 12; P. 10; V. 3.

Body very much compressed, rather elongate, thin and more or less rounded above; tapering below to an extremely thin drawn-out cutting edge; head tapering anteriorly into a long tubular snout, ending in a terminal mouth; dermal skeleton ends posteriorly in a long, sharply pointed spine; interorbital space rather flat, with a shallow median groove, both sides of which longitudinally striated; the rostral tube compressed into a cutting edge inferiorly; mouth extremely small, terminal, with no teeth; nostrils lateral, very close together, situated one before the other in front of the orbit; operculum ovate, longer than high, antero-inferior edge sharply pointed downward; sub-operculum broad anteriorly, tapering behind; præ- and inter-operculum united, thin and transparent, forming a broad membraneous margin below the throat; eye moderate, situated at the posterior one-fourth of the head.

The back of the trunk cuirassed by a bony sheath, which extends downward nearly to the middle of the sides, having a shallow notch before and above the pectoral; the cuirass produced posteriorly into a sharply pointed spine; it consists of four median pairs of narrow bones and six lateral ones of lamelliform shape, and of a single, long dagger-shaped bone which forms the dorsal spine, the sutures of all these bones deeply serrated except the dorsal median suture; lower half of the sides covered by a transparent tough covering, supported by ten ribs.

Close beneath the posterior spine the vertical fins are crowded; the spinous and soft dorsals point nearly straight backward, the caudal obliquely downward, and the anal straight downward; the pectoral inserted upon the middle of the sides above, the distance from the operculum equal to the length from the pre-orbital edge to the end of operculum, the distance between origin of pectoral and the tip of snouts equals the distance between the former and the root of the

first dorsal spine, uppermost ray the longest; ventrals rudimentary, inserted upon the carinated edge of abdomen, below the fifth rib, its distance from the anterior orbital rims equal to that to the root of the last anal ray; dorsal spines slender, inserted close together, connected with the dorsal spine and with one another by a transparent membrane, the uppermost spine much longer than the others; soft dorsal ray slender and long, reaching beyond the end of the caudal; caudal fin rather tiny, obtusely rounded.

Color in alcohol uniformly pale yellow, with no markings; the rostral tube, the place occupied by the air-bladder, and the broad membraneous edge of the lower parts transparent; terminal spine and all the fins whitish.

Total length 147 mm.

Described from a single specimen from Anpin near Tainan, collected by M. Watanabe in the year 1919.

Habitat: East Indies, north to Formosa.

2. **Centriscus capito** Ôshima, sp. nov. (Plate XIII, fig. 3.)
Taiwan Yoroi-uwo (Japan) (Formosan armour-fish).

Head 2.72 in the total length; depth 6.81; width of head 9.75 in its length; interorbital space 10.75; eye 10.75; 1.5 in postorbital part; D. III, 10; A. 12; P. 10; V. 4.

Body very much compressed, elongate, thin, and very slightly rounded above, tapering below to an extremely thin, drawn-out cutting edge; head tapering into a long tubular snout, having a small terminal mouth; dermal skeleton ends posteriorly in a sharply pointed, long spine; interorbital space rather flat, with a shallow median groove, both sides of which longitudinally striated; rostral tube compressed into a cutting edge inferiorly; mouth terminal, a single pore, with no teeth; nostrils lateral, close together, situated in front of the orbit; eye moderate, posterior; operculum ovate, slightly longer than high, antero-inferior edge acutely pointed downwards; suboperculum broad anteriorly, curved and tapering posteriorly; præ- and interoperculum united, thin and transparent, forming a broad membranous margin below the throat.

The back of the trunk cuirassed by a bony sheath, which extends downwards nearly to the middle of the sides, having a shallow notch before and above the pectoral; the posterior end of the cuirass pro-

duced into a strong spine; the cuirass consists of four median pairs of narrow bone and six lateral ones of the lamelliform shape, and of a single, long, dagger-shaped bone, forming the dorsal spine; sutures of all these bones deeply serrated except the dorsal median sutures; lower parts of the sides covered with a transparent tough covering, supported by nine ribs.

Close beneath the posterior spine the vertical fins are crowded; the spinous and soft dorsal point nearly straight backward, the caudal obliquely downward, and the anal straight downward; the pectoral inserted upon the middle of the sides above, the distance from the operculum equals the length of the orbit and the operculum taken together, the distance between the pectoral and the tip of the snout much exceeds the distance between the former and the root of the first dorsal spine, the fin rather long, the uppermost ray the longest; ventrals rudimentary, inserted upon the carinated edge of abdomen, below the fourth rib, its distance from the anterior orbital margin nearly equals the distance between the ventral and the soft dorsal base; dorsal spines rather slender, inserted close together beneath the base of the dorsal spine, connected with it and with one another by a transparent membrane, the first spine the longest, nearly twice as long as the third; soft dorsal rather slender, elongate, reaching beyond the tip of caudal; caudal fin quadrate, its tip obtusely rounded.

Color in alcohol pale yellow; rostral tube, the place occupied by the air-bladder, and the membraneous margin of the lower parts transparent; all the fins whitish.

Total length 108 mm.

Type: Described from a specimen from Tôkô, collected by A. Kihara, and now in the Carnegie Museum, Cat. of Fishes, No. 8287, marked "type specimen."

Habitat: Tôkô, a small town at the estuary of the Shimo-Tamusui River (three specimens).

The present species distinctly differs from *Centriscus scutatus* in the following points:

1. Head is longer, contained less than three in the total length.

2. Pectoral inserted much behind a point midway between the tip of snout and the root of the first dorsal spine.

3. Ventral is provided with four rays.

4. The distance between the ventral and the pre-orbital edge much longer than that between the former and the root of the last anal ray.

VIII. NOTES ON SOME SPECIES OF CHALCIDOIDEA IN THE CARNEGIE MUSEUM.

By Hugo Kahl.

The question of the identity and location of the type of the genus *Pentasmicra* Ashmead having been raised in a letter written by Mr. A. B. Gahan, of the United States National Museum, to Dr. W. J. Holland, the latter requested me to investigate the subject.

I discover that there is only one specimen labeled *Pentasmicra* in the collection upon which Ashmead founded his memoir upon the *Chalcidoidea* published by the Carnegie Museum (*Memoirs Carnegie Museum,* Vol. 1, 1904, pp. 225–551). On page 252 Ashmead states that the type of his new genus is "*P. brasiliensis* Ashmead." The single individual assigned to the genus *Pentasmicra* in the collection unfortunately bears no specific name on the label. It, however, agrees in the main with the diagnosis of the genus given on pages 252 and 455 by Ashmead. It can not possibly be referred to any of Walker's species of the genus *Smicra* (*Smicra*) referred by Ashmead to his new genus. It differs in size, as well as in its other features, from the insects named by Walker. There seems to be but one conclusion possible, and that is that Ashmead carelessly neglected to write the specific name upon the label, and that the specimen bearing the generic name in his own handwriting must be regarded as the type of the genus which he has erected in his work. If there were any other individuals of the genus in the collection, we would be left in doubt, but this unique specimen, bearing Ashmead's generic name, must be chosen as the *lectotype* and the specific name *brasiliensis,* which he gave it in his paper, should be supplied.

As Ashmead's description is generic, and he has failed to give in his work a close description of the insect, I supply the deficiency.

Pentasmicra brasiliensis Ashmead.

Pentasmicra brasiliensis Ashmead, Type, ♀. Length of body from front of head to the apex of the abdomen 6 mm. Color yellow. Occiput along the foramen with a transverse, black band, which is

very narrow at its middle and greatly expanded laterally. Scape of the antennæ yellow, bordered on the inner side with a black line; the flagellum below and the entire pedicel rufous; the rest of the flagellum above dusky brown, this color being more intense on the apical half. The distance between a posterior ocellus and the eye is distinctly less than the width of the ocellus. The left mandible is plainly bidentate; the dentition dark brown. The right mandible is concealed, but with the sides of its dark-brown apex seen in an oblique light at first glance presents the appearance of a third tooth, which may have misled Ashmead, as it at first misled me, until I examined the mandible of the opposite side. The middle lobe of mesonotum has a transverse black stripe, occupying a little more than one-third of the anterior margin, and two longitudinal outwardly curved, blackish lines, connected with the lateral ends of the antero-marginal stripe, and connected with each other at the posterior third of this lobe; thus the antero-marginal stripe and the two curved lines form together a circle, and from the posterior end of this circle extends apparently a blackish line to the posterior margin of the lobe. The pin has unfortunately been thrust through the body behind the circular mark, and this extended line can not be distinctly defined. Scapula with its anterior margin and a short longitudinal stripe near its inner margin blackish. Axilla with the inner corners black, this color extending narrowly across the anterior margin of the scutellum. Scutellum with a blackish, reverted T-mark, the stem of which, very narrow and pointed, reaches the anterior border; its rather short cross-line, pointed at each end, rests on the posterior fifth of the scutellum. The scutellum ends in a small slightly concave plate, the distal margin of which is gently emarginate, and its lateral, semitranslucent corners only slightly produced. The breast between the anterior and middle pairs of legs black, and this color extends dorsad along the anterior margin of episternum; the ventral portion of metathorax between the posterior pair of legs black. The posterior coxæ above with the apical socket black; the posterior femora each on inner side at base near dorsal margin with a short, longitudinal, blackish-brown stripe; they are armed along the externo-ventral edge with five strong teeth, which have their apical halves black; the distance between the two large basal teeth of both the femora is about twice as great as the distance between the other large teeth; the right femur has an additional,

sharply pointed, sixth tooth, small, but distinct, and situated midway between the two large basal teeth; on the left femur is seen an extremely minute, black tubercle between the two large basal teeth and immediately distad of the apical tooth a short, blunt, black tubercle; the two large basal teeth are acute, the third less so, and the fourth and fifth are blunt at apex; the posterior tibiæ narrowly bordered with black along the externo-ventral edge, and along the middle of the dorsal edge there is an oblong reddish-brown spot; tarsi with the extreme apex dark brown. Abdomen conical, its extreme apex black, reaching almost as far distad as the apices of the posterior femora, its petiole short, only as long as wide. Wings hyaline with brown veins, the marginal and post-marginal veins of nearly equal length, each about four times longer than the stigmal vein.

It is worthy of note that Ashmead says that the "eyes are large, occupying nearly the whole sides of the head," but in the specimen they are not more prominent and enlarged than in "*? Hexasmicra trinidadensis*" Ashmead, "*? Hexasmicra brasiliensis*" Ashmead, and Ashmead's species of the genus *Spilochalcis*. Ashmead did not take into consideration the irregularity in the dentition of the posterior femora of the specimen here treated when naming it *Pentasmicra*. He also places *Smicra cerina* Walker in *Pentasmicra*. Walker in his table does place it with those with five strong teeth on the hind femora, but in his description of *S. cerina* he writes: "hind-femora armed with six teeth, five of which are large."

Genus **Hexasmicra etc.**

When Ashmead (p. 252) erected the genus *Hexasmicra*, he chose as the type species *Smicra* (*Smicra*) *transversa* Walker, and on page 455 he referred with doubt to *Hexasmicra* two new species, *? Hexasmicra trinidadensis* Ashmead and *? Hexasmicra brasiliensis* Ashmead, each represented by a single specimen. The former is labeled by Ashmead "*Xanthosmicra trinidadensis* Ashm. type." *Hexasmicra brasiliensis* is so labeled, but without a question-mark and without "Type" written on the label. This seems to show that Ashmead was not quite satisfied with the generic position of the two species, and intended probably to remove them from association with Walker's dark, robust, and large species. Both of these two species of Ash-

mead are generically identical, and should they finally be removed from *Hexasmicra,* it would be proper to retain Ashmead's manuscript name *Xanthosmicra* with his *trinidadensis* as the type species. Both species differ from *Hexasmicra transversa* Walker in having the petiole long (pp. 454–455), the posterior femora abruptly widened from base, and the distance between a posterior ocellus and the eye scarcely as wide as the width of the ocellus. In *brasiliensis* the distance is distinctly less. In *H. transversa* Walker the petiole is not longer than wide (pp. 252 and 454); the posterior femora are gradually (not abruptly) widened from base; and the distance between a posterior ocellus and the eye is distinctly greater than the width of the ocellus. In *H. trinidadensis* the left mandible is bidentate (the right one is concealed). In *H. brasiliensis* the dentition can not be studied without relaxing the specimen. The types of both of these species have the femoral teeth black in their apical half. The two are closely related to the type of *Heptasmicra quadrimaculata* Ashmead (p. 453), which, in fact, is generically separated from them only by having a seventh, small femoral tooth between the two large basal teeth.

Leucospis enderleini Ashmead.

Leucospis enderleini Ashmead (*Memoirs Carnegie Museum,* Vol. I, p. 405, Plate XXXI, Fig. 1).—As Ashmead's description and figure do not agree, Mr. J. C. Crawford, of the United States National Museum, asked the writer some years ago to examine the type of *enderleini;* the writer did not find any specimen in the Carnegie Museum labeled *Leucospis enderleini,* but one female labeled "*Leucospis schletterer*i Ashm. type," and, as no species so named was described by Ashmead, the writer examined the one labeled *schletterer*i and found it to perfectly agree with the description of *enderleini.* There is not the slightest doubt that the specimen labeled *L. schletterer*i is the type of *L. enderleini,* and the length of the ovipositor is as described by Ashmead, but the figure is incorrect. Dr. Schletterer wrote extensively on *Leucospis,* and Ashmead was evidently thinking of Schletterer and wrote that name on the label instead of *enderleini.* This happened at a time when the great hymenopterist felt the effect of failing health. The writer has attached a corrected note to the specimen below Ashmead's label for the guidance for future students.

IX. THE GENUS DICYSTA CHAMPION (HEMIPTERA).[1]

By Carl J. Drake.

(One text-figure.)

The genus *Dicysta* was founded by Champion (Biologia Centrali-Americana, Hemipt.-Heteropt., Vol. II, 1897, p. 5, Pl. 1, figs. 4, 4*a*) upon a single specimen from Panama. As stated in the original description, the genus greatly resembles the more exaggerated forms of *Leptostyla,* except that the foliaceous median carina is developed behind into a large bladder-like structure. The latter inflated process appears very much like the hood in size and shape, and thus distinguishes *Dicysta* from *Leptostyla, Corythucha, Stephanitis,* and other closely related genera. The lateral carinæ are wanting.

The three species described herewith slightly modify the generic description. The hood is somewhat variable in shape and entirely covers the head. In *D. vitrea* Champion, *D. hollandi* n. sp., and *D. braziliensis* n. sp. the hood is connected posteriorly a little below its crest by the foliaceous median carina and the anterior portion of the median carina is areolate between the hood and its inflated posterior process. In *D. smithi* n. sp. the hood is connected posteriorly near its base by the median carina, and, on the other hand, the median carina is neither strongly raised nor areolate between its inflated posterior process and the hood. The paranota are more or less reflexed; the width and shape varies according to the species. The metasternal orifice is distinct, except in *D. vitrea,* where it is more or less distinct. The length of the rostrum and wings is somewhat variable. The elytra are twice as long as the abdomen, but the shape is quite variable. The head usually bears three frontal spines, one on each side of the median line, and a median spine placed a little above the lateral spines. The species are all neotropical and nothing is known concerning their food-plants and habits.

[1] Contribution No. 35 from the Department of Entomology, New York State College of Forestry, Syracuse, New York.

KEY TO THE SPECIES OF DICYSTA.

1. Median carina strongly raised and areolate between its inflated posterior process and the hood, connected with the latter a little below the crest; costal area with three or more rows of areolæ at its widest part.....2.

1a. Median carina neither foliaceous nor areolate between its inflated posterior process and the hood, connected with the latter at the base; costal area moderately wide, biseriate.....*D. smithi* n. sp. (No. 4).

2. Paranota moderately wide, only slightly reflexed, biseriate; elytra with rather small tumid elevations, the lateral margins diverging posteriorly to the rounded tips.....*D. braziliensis* n. sp. (No. 3).

2a. Paranota very wide, strongly reflexed, with four or five rows of areolæ; elytra with large tumid elevations, the lateral margins from about the basal third to the rounded tips, nearly parallel on posterior two-thirds...3.

3. Paranota shell-shaped, very strongly recurved, the under surface of the distal row of areolæ visible above.....*D. vitrea* Champion (No. 1).

3a. Paranota with the anterior and posterior margins very strongly recurved, the lateral margins not recurved at all (see fig. 1, *a* and *b*).
D. hollandi n. sp. (No. 2).

1. **Dicysta vitrea** Champion.

Dicysta vitrea CHAMPION, Biol. Centr.-Amer., Hemipt.-Heteropt., vol. II, 1897, p. 5, Pl. 1, figs. 4, 4a.

The type of this species, collected at Volcan de Chiriqui, Brazil, is figured and described by Champion in the Biologia Centrali-Americana. The species is closely related to *D. hollandi* n. sp., but readily separated from it by the structures mentioned in the key. The specimens at hand, collected by Mr. and Mrs. H. H. Smith during July, August, and October at Chapada, Brazil, differ slightly from the original description. The metasternal orifice is usually visible. The subcostal area has three rows of areolæ at its widest part. In all specimens before me the head has three obtuse frontal spines, but they are variable in size and not very prominent in a couple of the specimens. According to the original description the type has only a median obtuse frontal spine, the subcostal area two rows of areolæ and the metasternal orifices are not visible. The fourth segment of the antennæ is slightly swollen, brownish, clothed with a few hairs, and about one-half as long as the third.

2. **Dicysta hollandi** n. sp. (Fig. 1, *a* and *b*.)

In general facies and shape of the elytra, very closely related to *D. vitrea,* but easily distinguishable by the structures mentioned in the key, the size of the hood, and shape of the inflated portion of median carina. Length 2.92 mm.; width 1.7 mm.

Head with three frontal spines, the tips of the latter not quite reaching the middle of the first antennal segment. Antennæ long and slender, the third segment slightly curved and almost twice as long as the fourth; fourth segment only slightly enlarged, clothed with a few long hairs. Rostrum reaching almost to the end of the mesosternum. Elytra formed as in *vitrea,* but with the subcostal area biseriate and the tumid elevations slightly smaller, costal area broad, with five rows of areolæ at its widest place. Wings a little longer than the abdomen. Pronotum very coarsely punctate; paranota broad, with four rows of large areolæ, the anterior and posterior margins recurved (See fig. 1, *a* and *b*). Hood a little larger than in *vitrea* and a little longer than high; inflated portion of median carina with the anterior margin nearly truncate and slightly sloping obliquely upwards caudad.

General color of *vitrea* Champion, but without the faint transverse

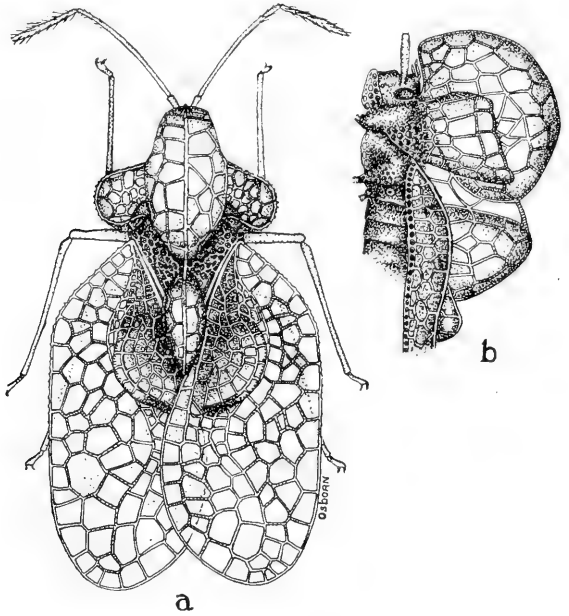


FIG. 1. *Dicysta hollandi* Drake, n. sp. *a,* dorsal view; *b,* lateral view of hood and inflated portion of median carina.

band on the costal area. Described from three specimens, two from Chapada and the other from Santarem, Brazil, collected during August by Mr. and Mrs. H. H. Smith. The species is named in honor of Dr. W. J. Holland, who kindly has sent me for study the specimens of neo-tropical Tingidæ in the Carnegie Museum. *Type* from Chapada, Brazil, in Carnegie Museum; *paratypes* in Carnegie Museum and author's collection.

3. **Dicysta braziliensis** n. sp.

Related to *D. vitrea* Champion and *D. hollandi* n. sp., but very distinct and readily separated from either of these forms by the much narrower paranota, and the much less elevated hood and bladder-like process of the median carina; the elytra are widened posteriorly. Length 2.79 mm.; width 2.09 mm. (through tumid elevations of elytra).

Head with three moderately long frontal spines, the lateral ones directed inwardly with their points touching, the median closely appressed to the surface of the head. Antennæ with the first segment about three times the length of the second, the third and fourth segments wanting. Rostrum reaching a little beyond the meso-metathoracic suture, pronotum rather coarsely punctate, paranota slightly reflexed, narrow, biseriate, the areolæ moderately large, but smaller than those of the hood. Hood very long, with the sides slightly compressed, shaped very much like the hood in *Corythucha* (hood entirely covers the head, but placed much farther back on the pronotum) nearly twice as long as high. Posterior hood-like process of median carina with its height and length subequal, about half as long as the hood, the anterior margin nearly truncate and sloping obliquely backwards. Median carina connected with the hood a little below the crest, with three large areolæ between hood and inflated portion of median carina, and with three small areolæ under the raised posterior portion of hood, with the sides somewhat compressed, narrower than the hood, rounded posteriorly. Elytra widened posteriorly, widest near the apex; costal area with five rows of areolæ at widest part (one at base and enlarging to five at widest part); subcostal area with a single row of areolæ at the base and enlarging to two posteriorly; tumid elevations not very large; discoidal area broadly rounded distally, with four rows of cells at widest part. Wings a little longer than the abdomen.

General color brownish. Body beneath dark brown or blackish, the abdomen lighter. Basal segments of the antennæ dark brown. Nervures of paranota, elytra, hood, and median carina dark brown, part of them more or less testaceous. Legs brownish.

Described from a single male specimen (*type*), taken at Santarem,

Brazil, in Carnegie Museum. This species is so very distinct that I feel entirely justified in describing it from a single example.

4. **Dicysta smithi** n. sp.

Differs from *D. vitrea* Champion and the new species described above by its much narrower form, the biseriate costal area, and the pyriform shape of the hood. The median carina is not strongly raised nor areolate between its inflated posterior process and hood, and, moreover, it is connected with the latter structure at the base. Length 3.34 mm.; width 1.32 mm.

Moderately elongate and oblong. Head with three porrect frontal spines, the median a little longer than the lateral ones and not quite as long as the first antennal segment. Rostrum reaching to the meso-metasternal suture. Antennæ long and slender, the third segment slightly curved and two and two-thirds times the length of the fourth; fourth segment a little swollen, clothed with numerous short hairs, a little more than twice as long as the first and second segments taken together. Hood moderately large, pyriform, its height slightly greater than its length and one and two-fifths times its width. Posteriorly bladder-like process of median carina a little higher and longer than the hood, rather broadly rounded above, the sides somewhat compressed and much narrower than the hood. Paranota moderately wide, not strongly reflexed, mostly triseriate, the areolæ along the outer margin much larger than the others. Pronotum coarsely punctate, shining. Wings considerably longer than the abdomen. Elytra widest a little in front of the middle, broadly rounded at the tips; costal area moderately wide, biseriate, the areolæ large and mostly pentagonal; subcostal area with three rows of areolæ at its widest place; tumid elevations moderately large, occupying most of subcostal and discoidal areas.

General color testaceous, the areolæ hyaline and somewhat iridescent. Legs and antennæ yellowish brown, the apical segment of the latter entire brown. Pronotum brown. Body beneath dark brownish, slightly tinged with red, the eyes black. A few nervures on tumid elevation and a clouded spot in sutural area fuscous.

Described from three females, taken during July by Mr. and Mrs. H. H. Smith at Chapada, a small village of Matto Grosso, Brazil, about 25 miles E. N. E. of Cuyabá. *Type* in Carnegie Museum; *paratypes* in Carnegie Museum and author's collection.

X. AN ANNOTATED LIST OF FOSSIL PLANTS OF THE DAKOTA FORMATION (CRETACEOUS) IN THE COLLECTIONS AT THE CARNEGIE MUSEUM, INCLUDING DESCRIPTIONS OF THREE NEW SPECIES.

By E. M. Gress, Ph.D.

(Plates XIV and XV.)

Introductory.

The present paper embodies the results of an investigation carried on in the Carnegie Museum under the direction of Dr. O. E. Jennings and counted as a minor study in the Graduate School of the University of Pittsburgh in candidacy for the Degree of Doctor of Philosophy. A report of this investigation was given before the Paleontological Society of America at the Pittsburgh meeting, held December 31, 1917, to January 2, 1918, but since that time has been considerably elaborated.

The specimens studied consist of leaf impressions, mostly in a rather coarse-grained sandstone known as the Dakota Sandstone, from Ellsworth County, Kansas. Most of the specimens were obtained by the Carnegie Museum when it acquired the collection of Baron de Bayet; others were obtained a number of years ago by exchange with the National Museum, while a few others are of miscellaneous provenance, acquired in various ways, as may be noted in the references to the specimens under the respective species in the accompanying list.

While of necessity considerable time was consumed in studies relating to the stratigraphy and correlation of the Dakota and other adjacent formations, in order that the literature might be used with facility and some considerable degree of assurance, nevertheless the studies were carried out more from the standpoint of a botanist than of a geologist. The work was done in the Herbarium of the Carnegie Museum, where constant reference was possible to specimens in connection with the more detailed studies of venation and other characters of the leaves of certain species, or groups of species.

To simplify and to make more certain the reference to the various specimens a number has been attached to each. This reference number appears in parentheses in the citation of specimens under the various species in the accompanying list.

Grateful acknowledgment is hereby made to the authorities at the Carnegie Museum for the privileges and facilities afforded for carrying on these studies, and to Dr. O. E. Jennings for his ever-ready helpfulness and general supervision.

BRIEF HISTORICAL NOTES RELATING TO STUDIES ON THE DAKOTA FORMATION.

During the past sixty years much has been written on the "Dakota Formation," including its geological characteristics, age, relationship, and content.

No attempt will be made here to give a complete summary of the history of this very important formation, but a very brief outline of the more important points in its history and development will be reviewed in order to recall its location and correlation with other formations. The history of the "Dakota Formation" really begins with the year 1853, when Prof. Meek and Dr. Hayden were sent by Professor Hall of Albany on an expedition to the Bad Lands of Nebraska, which at that time included all of the upper Missouri country, for the purpose of collecting Tertiary vertebrate remains.

On this trip many Cretaceous remains were collected at Sage Creek, Great Bend, and other places. Along the Missouri from Ft. Pierre to Belleview, a trading post a short distance above the present site of Omaha, much attention was given to the lithological character, order of succession, and characteristic fossils of the subdivisions of the Cretaceous series. (U. S. Geological Survey of the Territories, IX, 1876, p. 22.)

An account of the fossils brought back by this expedition was published in the *Memoirs* of the American Academy of Arts and Sciences, Boston, Volume V, 1856.

Five divisions of the Cretaceous period of this region were formed from the notes and were published in the same Memoir, p. 405.

In subsequently published papers by Meek and Hayden these five divisions were amplified. Finally in 1861 the following names were

given to the series and subdivisions (*Proceedings Academy Natural Sciences of Philadelphia,* p. 419):

Upper Series.
Formation No. 5, Fox Hill Group.
Formation No. 4, Fort Pierre Group.

Lower Series.
Formation No. 3, Niobrara Division.
Formation No. 2, Fort Benton Group.
Formation No. 1, Dakota Group.

This is undoubtedly the first use of the term "Dakota." As is shown, this formation was from the first included in the Cretaceous, although some writers, particularly in Europe, thought it belonged to the Miocene Age, while others placed it in the Triassic or Jurassic. For a detailed account of the great controversy which took place concerning the age of the Dakota Formation see Gould, Charles Newton, *The Dakota Cretaceous of Kansas and Nebraska,* Kansas Academy Science, Transactions, XVII, 1901, pp. 122–178. Also Bain (Iowa Geological Survey, V, 1895, p. 267), who gives an excellent review of the Dakota Formation of Iowa, including a great many references.

While the name has not been changed, still very much more is known about the exact relationship and boundary lines of the "Dakota Formation" than was known at the time the name was first used.

In the U. S. Geological Survey, IX, Pls. 1 and 2, fossils are figured from the alleged "Dakota Formation." One of these represents the fauna of the typical Dakota locality in Nebraska, the other represents the fauna of the Dennison beds of the Comanche series in Kansas, the existence of this series not then being known in America.

The author of the term "Dakota Formation" did not know that he was including within it two distinct formations and faunas, as has been proven by recent discoveries in the Texas region and other parts of the Rocky Mountain region.

The original definition and description of the Dakota Group were based upon the Big Sioux River locality where the earlier Cretaceous beds were not present. Since it was found in the type-locality to rest upon pre-Cretaceous rocks, it was thought to form the lowermost layers of the Cretaceous rocks. By more recent discoveries, it is now known, where there have been no interruptions in the successive for-

mations, to pass conformably upward into the Colorado division and to rest upon earlier Cretaceous (Comanchean) beds. In some places, however, it overlaps the earlier Mesozoic and Paleozoic formations and rests on the Archean (Chamberlain and Salisbury's Geology, Vol. III, p. 144).

The present position of the Dakota Formation is now known to be in the Upper Cretaceous, and, as has been shown in the Rocky Mountain and Texas regions, the Lower Cretaceous, or what has been called the Comanchean Series, lies between the Dakota and pre-Cretaceous formations. Thus it will be seen that the meaning and application of the term "Dakota" is not exactly the same as it was when it was first used by the author. ("The term 'Dakota,' its origin, definition, and application." 21st Annual Report, U. S. Geological Survey, Part 7, 1899, 1900, p. 318.)

The term Dakota may still be used in a more limited sense, as is shown by the fact that Ward in 1893 discovered that the Dakota sandstone of the Black Hills contained not only a Dakota flora, but other floras of later age. The stratigraphy showed that the upper sandstone is separated from the lower by an intermediate layer of shale which was called the Fuson Formation. The lower layer of sandstone was called the Lakota Formation. The term Dakota was applied only to the uppermost layer of sandstone (Darton, U. S. Geological Survey, Professional Paper No. 32, 1905, p. 165).

"The tripartite composition of the old 'Dakota' group in the Black Hills is very distinct throughout the uplift and apparently is a widespread feature in the adjoining regions." (Darton, *op. cit.*) The Fuson and Dakota beds are classified by Knowlton as correlated with the Kootenai and the Morrison of the Comanchean Period. (See "Plant Successions" by Clements, 1916, p. 443; also Cleland, "Geology Physical and Historical," 1916, p. 515.)

Botanically the history of the "Dakota Formation" begins with 1866, when leaves, collected by Messrs. Marcou and Capellini, were figured and described under seventeen different species by Professor Heer in a paper entitled "Les Phyllites Crétacées du Nebraska."

In 1868 Dr. Newberry described some leaves collected by Meek and Hayden from the "Dakota Formation." A series of plates was made which was intended to be published in Volume VIII of the Geological Survey of the Territories, but this was not done.

In 1878 Hayden published 500 copies of the plates under the title of "Illustrations of Cretaceous and Tertiary Plants."

In 1874 Lesquereux published his "Cretaceous Flora." Other publications followed by Lesquereux, and in 1885 he began his work on the "Flora of the Dakota Group." This was submitted to the publishers in 1888, but before it was published Lesquereux died (1889).

The book was published three years later (1892) by Dr. Knowlton. Many other writers have contributed short articles on the "Dakota Group," but very few species, not described in the "Flora of the Dakota Group," have been added to the large number of species figured and described in this admirable work.

Deposition and Present Distribution of the Dakota Formation.

The "Dakota Formation" is found in the middle western part of North America. It is rather extensive in the Great Plains, but is mostly buried by later formations (Chamberlain and Salisbury's Geology, Vol. III, 1906, p. 144). The type locality is Sioux City and Blackbird Hill, where, with other portions of Kansas and Nebraska, it is found in comparatively large areas. It extends west of the Rocky Mountains, but is interrupted by high elevations along these mountains. It has been found distributed in portions of Kansas, Nebraska, Minnesota, South Dakota, Wyoming, Colorado, Oklahoma, New Mexico, and other States. North of the United States it apparently has been found in the Frazer River Valley and in the eastern part of Crow's Nest Pass. (See Dawson, Bulletin Geological Society of America, XII, pp. 77–78.)

Knowlton, in discussing the succession and range of the Mesozoic and Tertiary floras, says that in the interior of North America, in approximately the same position as the Magothy of the Atlantic border, "is the Dakota, which has afforded a splendid flora of over five hundred species, and occurs in Kansas, Nebraska, Wyoming, Minnesota, along the international boundary, and some of the same forms as far as central Alaska and south to Argentina." ("Outlines of Geologic History," Willis and Salisbury, 1910, p. 206.)

The formation is chiefly non-marine, consisting largely of sandstone, with conglomerate, clay, and a little lignite. The deposition took place evidently in the shallow water of lakes, rivers, and marshes.

Some marine fossils are found in the uppermost parts of the formation. The four epochs of the Upper Cretaceous period of the Rocky Mountain region seem to be sufficient proof of submergence followed by emergence, the Dakota being chiefly a fresh-water formation, the Colorado and Montana salt-water formations, and the Laramie, the western coal epoch, a fresh-water formation.

In discussing the "Dakota Formation," Chamberlain and Salisbury ("College Text-book of Geology," 1909) say: "The formation was formerly regarded as lacustrine, but it is perhaps to be regarded rather as the joint product of subaërial and fluviatile deposition. The presence of bird tracks in Kansas, and the widespread abundance of fossil leaves of angiosperms, in a condition which precludes much transportation, imply subaërial sedimentation to a notable extent at least." For the deposition of the Dakota Group in Iowa, see Calvin, Iowa Geological Survey, 1, 1892, p. 132.

Since the fossil leaves described in the following pages were collected chiefly in Kansas (Ellsworth County and Fort Harker), we give here a more detailed account of the location of the Dakota Group in that State.

The central, northern, and western parts of the State of Kansas are underlain by the Dakota sandstone. The depth varies from about 1,000 ft. in the central northwestern counties to probably 2,500 ft. in the northwest counties. In Ellsworth County, near the central part of the State, and the place from which most of our fossil leaves have been collected, the sandstone lies at or near the surface, except in the deeper parts of Smoky Hill Valley, in the southeastern part of the county, where the underlying Permian rocks are exposed.

It varies from a few feet to about 600 ft. in thickness, and outcrops in a zone from about 12 to 30 miles in width, extending from Washington County in a southwesterly direction to the Arkansas River in Rice and Benton counties. From here it extends in an easterly direction up the Arkansas River to Ford County, where it is covered by Tertiary deposits.

It again appears near the Colorado State line along the valleys of the Cimarron River and some of its branches. In northwestern Kansas the "Dakota Formation" is underneath the Benton, Niobrara, Pierre, and Tertiary formations. It probably lies 2,000 ft. below the surface in the extreme northwestern corner. In the north-central

part of the State it lies on the Wellington formation, and in the south and southwestern parts on the Cimarron formation, with Kiowa and Cheyenne of the Lower Cretaceous intervening at certain places. See N. H. Darton, United States Geological Survey, Professional Paper No. 32, 1905, from which also the table given on p. 282 is taken, giving the geological formations in central and western Kansas.

CORRELATION OF THE DAKOTA FORMATION.

There is still some uncertainty as to the exact correlation of the flora of the Dakota Formation with other Cretaceous formations of America; still greater is the uncertainty of its correlation with the floras of the Old World.

One of the strongest evidences of the correlation of different formations is derived from the animal remains found in the rocks. Unfortunately very few animal fossils have been found in the Dakota Formation. Stanton, in his "Succession and Distribution of Later Mesozoic Invertebrate Faunas in North America" ("Outlines of Geologic History" by Willis and Salisbury, 1910), says: "The invertebrate fauna of the Dakota sandstone is too meager to be of much value. It consists of a few brackish-water species with *Unio* and a few other fresh-water shells in other strata and at the top some marine species, that probably really belong with the succeeding Colorado fauna."

In our study of this collection of plants we have discovered no facts, which add anything new to our knowledge of the correlation of the Dakota with other Cretaceous formations. The following, therefore, is merely a summary of the opinions given by those who have made careful comparisons of the Dakota Formation with other formations of the Cretaceous period.

In discussing the flora of the Raritan Formation, Berry (Geological Survey of New Jersey, Bulletin 3, 1911, pp. 20–22) incidently mentions the correlation of the "Dakota Formation" in the following manner: "European paleontology furnished abundant and well-characterized Cenomanian and Senonian floras for comparison, and by this standard the Raritan, as well as the somewhat younger Dakota and Magothy floras, are clearly Cenomanian floras." He further says that the Woodbine, Tuscaloosa, Eutaw, Middendorf, Bladen, and Magothy floras are southern and eastern representatives of the Dakota Group.

Newberry, in the "Flora of the Amboy Clays," U. S. Geological Survey, Monograph XXVI, 1895, p. 33, says: "We may fairly infer that the collection of plants from the New Jersey clays, the Dakota Group, the Patoot and Atane beds of Greenland, the Aachen series of Germany, and the plant-bearing Cretaceous rocks of Bohemia fairly represent the vegetation of the world during the middle and later portions of the Cretaceous age."

The location of the Dakota Formation in the Cretaceous series and its correlation with other formations can probably be best shown by the following tables and outlines.

The Cretaceous of Continental Europe is shown in the following outline (see "Traité de Geologie" by Lapparent, Vol. III, 1906):

Upper Cretaceous.

- Danian.
- Senonian.
- Turonian.
- Cenomanian.

Lower Cretaceous.

- Albian.
- Aptian.
- Barremian.
- Neocomian.

Table No. 1 (see p. 283) is compiled from the various tables given by C. A. White, U. S. Geological Survey, Bulletin 82, 1891. At the top of each column is given the number corresponding to the section given in the following explanation:

I. Meek and Hayden's Upper Missouri River Section.
II. General Section of the Upper Cretaceous for the Great Interior Area by Elridge.
III. The New Jersey Section, Cook and Rodgers.
IV. Smith and Johnson's Alabama Section.
V. Hilgard's Mississippi Section.
VI. The East Texas Section.
VII. The West Texas Section.
VIII. The North Mexican Section.

IX. Newberry's New Mexican Section.
X. Cope's General Section.
XI. The Eastern Colorado Section.
XII. King's 40th Parallel Section.
XIII. Powell's Uinta Section.
XIV. White's Northwest Colorado Section.
XV. North Interior General Section.

GEOLOGICAL FORMATIONS OF CENTRAL AND WESTERN KANSAS.
(Adapted from N. H. Darton, 1905.)

	Name	Principal Characteristics.
Quaternary	Sand Hills	Sand mainly in dunes, due to wind action.
	Alluvium	Sand, loam, and gravel in valleys; talus on slopes.
	Loess	Fine sandy loam, of pale brownish buff color.
	Equus beds	Sands and sandy clays.
Pliocene	Ogallala formation Comprising Tertiary	Calcareous grit, sandy clay, and sand.
	Grit, mortar beds, etc.	
Upper Cretaceous	Pierre Shale	Dark gray shale or clay.
	Niobrara Formation	Chalk, soft limestone, and shales.
	Benton Group	Shales, limestones, and sandstones.
	Dakota Sandstone	Sandstone and shale.
Lower Cretaceous	Kiowa-Cheyenne (Later Comanche) Series	Sandstone and shales.
Carboniferous	Cimarron Series (Permian)	Red sandstone and shales.
	Permian	Shales and limestones.
	Cottonwood limestones	Limestone.
	Waubaunsee group	Limestones, shales, sandstones, and thin coal-beds.

UPPER CRETACEOUS OF NORTH AMERICA.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
							Equivalent of Montana, Colorado, and Dakota Formations							
Dakota Group	Dakota Formation	Raritan and Amboy Clays	Upper portion of Eutaw Group	Tombigbee Sand	Timber Creek Formation	Equivalent of the "Pon-derosa Marls" and Austin, Eagle Ford, and Timber Creek Formations	Laramie	Lower Cretaceous	Dakota Group	Denver Arapaho Laramie	Laramie Group	Point of Rocks Group	Laramie Group	Laramie Formation
Ft. Benton Group	Colorado Formation	Clay Marl and	Rotten Limestone	Rotten Limestone Group	Eagle Ford Formation			Middle Cretaceous	Niobrara Group / Ft. Benton Group	Colorado Formation	Colorado Group	Sulphur Creek Group	Colorado Group	Colorado Formation
Niobrara Group		Lower Marl Bed												
Ft. Pierre Group	Montana Formation	Middle Marl Bed		Ripley Group	Ripley Formation "Pen-derosa Marls" and Austin Formation	Eagle Pass Beds		Upper Cretaceous	Ft. Pierre Group	Montana Formation		Salt Wells Group	Fox Hill Group	Montana Formation
Fox Hill Group		Lower part of upper Marl Bed							Fox Hill Group		Fox Hill Group			
	Laramie Formation		Hiatus		Hiatus	Laramie	Laramie		Puerco and Laramie	Denver Arapaho Laramie	Laramie Group	Point of Rocks Group	Laramie Group	Laramie Formation

CRETACEOUS PERIOD.—EPOCHS AND FORMATIONS IN THE UNITED STATES AND CANADA.

(Adapted from F. E. Clements, 1916.)

	Atlantic	Gulf	Rocky Mt.			Pacific	Colorado			Wyoming		Montana		Canada
Eocene		Eocene					Eocene							
	Peedee		Laramie				Laramie			Lower Laramie				
	Matawan	Ripley and Selma		Fox Hill				Fox Hill		Fox Hill		Fox Hill		Fox Hill
Cretaceous	Black Creek		Montana	Pierre	Bear Paw		Montana	Pierre	Vermejo	Pierre	Lewis	Pierre	Bear Paw	Belly River
		Middendorf			Judith River				Mesaverde		Mesaverde		Judith River	
	Magothy				Claggett				Mancos		Mancos		Claggett	
					Eagle								Eagle	
		Eutaw	Colorado	Niobrara			Colorado	Niobrara		Niobrara		Niobrara		Niobrara
		Tuscaloosa		Benton				Benton		Benton		Benton		Benton
	Raritan	Washita	Dakota				Dakota			Dakota, Bear River		Dakota		Mill Creek
	Comanchean	Comanchean												

Table No. 2 (see p. 284) is taken from Clements, "Plant Successions," 1916, and shows the Cretaceous period, epochs, and formations, approximately in their relation to each other at the present time.

In comparing the two tables it will be seen that changes have been made, as additional formations have been discovered and named, and new correlations have been made in the light of recent investigations.

In reviewing these tables, outlines, and expressions of opinion of various authors, it is seen that there is still some uncertainty about the correlation of the Dakota Formation, and that progress is still being made in such correlation.

We can conclude, however, that the Dakota Formation is pretty closely related to the Raritan, Amboy, Woodbine, Tuscaloosa, and Washita of the Atlantic and Gulf region, while the Magothy, Middendorf, and Eutaw may be somewhat younger. The Patoot and Atane beds of Greenland and the Mill Creek beds of Canada are evidently of about the same age. In Europe it is closely related to the Cenomanian or the lowermost division of the Upper Cretaceous. (See Dr. Horion's description of the structure and relation of the Aachen beds in his "Notice sur le Terrain Crétacée de la Belgique et de la France," 2me. Série, XVI, 1859, pp. 635–666.) In South America, in the southwestern part of Patagonia, a dicotyledonous flora, apparently of about the same age as that of the Dakota formation, has been found, and this has been included in the Cenomanian division of the Upper Cretaceous. (See Lapparent, Traité de Geologie, Vol. III, 1906, p. 1409.)

ANNOTATED LIST OF SPECIES.

CONIFERALES.

Family TAXACEÆ.

Genus BRACHYPHYLLUM.

1. **Brachyphyllum crassum** Lesquereux (?).

Thuites crassus LESQUEREUX, Cretaceous and Tertiary Floras, U. S. Geological Survey, VIII, 1883, p. 32.

Brachyphyllum crassum LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 32, Pl. 2, fig. 5; NEWBERRY, The Flora of the Amboy Clays, U. S. Geological Survey, Monograph XXVI, 1895, p. 51, Pl. 7, figs. 1–7.

Description: Our specimen is a portion of a cone (?). It is a mere fragment, which can not be classified with any degree of certainty. It resembles somewhat fig. 3, Pl. 7, Newberry, *op. cit.*

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 69*).

Family PINACEÆ.

Genus SEQUOIA.

2. **Sequoia Reichenbachi** (Geinitz) Heer.

Sequoia Reichenbachi (GEINITZ) HEER. For reference and distribution see BERRY, Bulletin New York Botanical Garden, III, Nov. 11, 1903, pp. 59, 60; also the Flora of the Raritan Formation, Geological Survey of New Jersey Bulletin, III, 1911, p. 93.

Description: The specimen, which contains well-preserved branches with leaves, a branch with leaves and a pistillate cone at the end, and two staminate cones, is found on a gray sandstone (?) collected in 1903 by Earl Douglass at the head of Jack Creek Canyon, Madison Mt., Montana. Mr. Douglass gives the horizon as "Dakota?" There is, I think, no doubt that the horizon has been correctly identified by Mr. Douglass. Since the species is found in the United States, Canada, Greenland, and Europe, and apparently ranges from the upper part of the Jurassic through the whole of the Cretaceous, it is impossible to say with positive certainty, from such an isolated specimen, whether it belongs to the Dakota, or to some other formation.

SALICALES.

Family SALICACEÆ.

Genus POPULUS.

3. **Populus Berggreni** Heer.

Populus Berggreni HEER, LESQUEREUX, The Geological and Natural History Survey of Minnesota, III, Part 1, 1885–1892, p. 13, Pl. B, fig. 3; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 42, Pl. 8, figs. 2–4.

Description: "Leaves subcoriaceous, oval, equally narrowed upward

to a blunt apex, and downward to a long petiole, entire; median nerve strong; secondaries thin; slightly curved in passing toward the borders, camptodrome." Our specimen is about 7 cm. long and 3.5 cm. wide near the middle of the blade. In shape and veining it resembles very closely the Minn. specimen, Pl. B, fig. 3, *op. cit.* Part of the apex and part of the base are wanting. The veining and areolation are very distinct.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 30*). Also north side of the Big Cottonwood River, near New Ulm, Minn.

4. **Populus kansaseana** Lesquereux.

Populus kansaseana LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 42, Pl. 17, figs. 1–7.

Description: The petiole of our specimen is wanting. The leaf is 5.5 cm. in length and 2.4 cm. in width a little below the middle. It is ovate lanceolate, acuminate, rounding to the petiole, entire. The midrib is comparatively heavy below, but becomes very thin toward the apex. The secondaries are not distinct toward the apex, but there are about six pairs. The lowermost pair is opposite and suprabasilar, with a thin, basilar nerville underneath, which fits exactly with Lesquereux's description, *op. cit.* According to Lesquereux's figures, the leaf must vary considerably. Our leaf, which shows both upper and lower surfaces, varies a little from any figured by Lesquereux. Its broadest part is a little below the center and it seems to taper more gradually to the apex, which seems to be a little longer and more pointed than those figured. I think, however, the evidence is sufficient to refer the leaf to this species.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa.

Nos. *40* and *40a* are the upper and lower parts of the same nodule; *40c* is a smaller leaf of the same collection. A fourth specimen (*40b*) is from the U. S. National Museum (C. M., Accession No. 4799).

Genus POPULITES.

5. **Populites elegans** Lesquereux.

Populites elegans LESQUEREUX, American Journal of Science and Arts (Second Series), XLVI, 1868, p. 94; Cretaceous Flora, Report of the Geological Survey of the Territories, VI, 1874, p. 59, Pl. 3, fig. 3; The Flora of the Dakota Group, U. S. Geological Survey Monograph XVII, 1892, p. 47, Pl. 46, fig. 5, and Pl. 47, figs. 2, 3; Geological and Natural History Survey of Minnesota, III, 1893, p. 10, Pl. A, fig. 2 and Pl. B, fig. 1.—NEWBERRY, The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, p. 54, Pl. 8, fig. 3.

Description: The leaf is orbicular in shape, about 10 cm. long and a little wider. The apex is very broadly rounded; the base somewhat cuneate. The margin is undulate or slightly denticulate. The first pair of secondaries are basilar or nearly so, but rather indistinct. The remaining four or five pairs are distinct, alternate, and branched. The areolation is rectangular and distinct. The leaf resembles very closely in shape, veining, and areolation that of Lesquereux's shown in Pl. 47, fig. 3, Flora of the Dakota Group, *op. cit.*

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 24*). A slightly smaller specimen (*No. 24a*) is also in the collection.

6. **Populites litigiosus** (Heer) Lesquereux.

Populites litigiosa HEER, in NEWBERRY, Illustrations of Cretaceous and Tertiary Plants of the Western Territories of the U. S., 1878, Pl. 3, fig. 6.

Populites litigiosus (HEER) LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 46, Pl. 7, fig. 7; Pl. 8, fig. 5; and Pl. 46, fig. 6 and Pl. 47, fig. 1.

Description: The leaf is orbicular-oval, entire, about 8.5 cm. long and 8 cm. wide, with about five pairs of secondaries. The lowermost secondaries are opposite, the uppermost subalternate. There is a smaller pair of secondaries joining the midrib a short distance below the first large pair. The secondaries are parallel, straight or nearly so, ramose, craspedodrome, distinct, but becoming very thin and indistinct toward the borders. The veining of the leaf resembles very closely Newberry's fig. 6, Pl. 3, *op. cit.* In shape it resembles Lesquereux's fig. 7, Pl. 7, *op. cit.*

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 27*).

Genus SALIX.

7. **Salix proteæfolia** var. **linearifolia** Lesquereux.

Salix proteæfolia var. *linearifolia* LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 49, Pl. 44, figs. 1–3.

Description: Our specimen shows only the lower portion of the leaf. The venation is not visible. The portion is about 5 cm. long and nearly 1.5 cm. wide near the broken end, which probably is near the middle of the leaf. I think there is no doubt that the specimen is a willow, but since the entire apex is gone, I am not positive about the variety. The leaf resembles in outline *linearifolia*, but is a little wider than those figured by Lesquereux, *op. cit.*

Occurrence: Ellsworth County, Kansas (?), Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 65*).

JUGLANDALES.

Family JUGLANDACEÆ.

Genus JUGLANS.

8. **Juglans arctica** Heer.

Juglans arctica HEER, Flora Fossilis arctica, VI, Abth. 2, 1882, p. 71, Pl. 40, fig. 2, and Pl. 41, fig. 4c, and Pl. 42, figs. 1–3, and Pl. 43, fig. 3.

LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 68, Pl. 19, fig. 3, and Pl. 39, fig. 5.

NEWBERRY, The Flora of the Amboy Clays, U. S. Geological Survey, Monograph XXVI, 1895, p. 62, Pl. 20, fig. 2.

HOLLICK, Annals N. Y. Academy of Science, 11, 1898, p. 58, Pl. 5, fig. 7; Additions to the Paleobotany of the Cretaceous Formation on Long Island, 3, Reprint from Bulletin of the N. Y. Botanical Garden, VIII, No. 28, Nov. 21, 1912, p. 157, Pl. 164, figs. 3, 4; The Cretaceous Flora of Southern N. Y. and New England, U. S. Geological Survey, Monograph L, 1906, p. 54, Pl. 9, figs. 6–8.

BERRY, The Flora of the Cliffwood Clays, Geological Survey of N. J., Part

2, 1905, p. 139, Pl. 21, fig. 1; Bulletin of the Torrey Botanical Club, XXXIII, 1906, p. 170; The Flora of the Raritan Formation, Geological Survey of N. J., Bulletin III, 1911, p. 110; The Upper Cretaceous and Eocene Floras of South Carolina and Georgia, Professional Paper 84, 1914, p. 30, Pl. 8, figs. 1, 2.

Ficus atavina HOLLICK, Transactions New York Academy of Science, 11, 1892, p. 103, Pl. 4, figs. 4–6.

Description: The following is Heer's description, written in 1882: "Nuce ovali, 34 mm. longa, 17 mm. lata; foliis magnis, foliolis ovalibus, basi inæquilateralibus, integerrimis, nervo medio valido, nervis secundariis angulo semirecto egredientibus, curvatis."

Our specimen is not quite complete at the apex and base. It is about 9 cm. long and 3.3 cm. wide a little below the middle. It is oblong, tapering to the apex, and narrowed toward the petiole, entire, slightly unequal. The midrib is strong below, becoming rather faint toward the apex. There are about twelve pairs of secondaries emerging at an angle of about 60 degrees, curved toward the margin, camptodrome. The areolation is not distinct. It is rather difficult, from the indistinct nervilles, to determine the species, but I think there is no doubt about the genus, judging from the general character of the leaf and the secondaries. Berry says in Bulletin Torrey Botanical Club, *op. cit.*, "A rather curious point of identity is the fact that the Greenland, New Jersey, and Kansas leaves are all inequilateral."

Occurrence: The leaf has quite a wide distribution. It has been reported from the Dakota Sandstone, ten miles northeast of Delphos, Kansas. Our specimen comes from Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 54*).

FAGALES.

Family BETULACEÆ.

Genus BETULITES.

The collection contains thirty specimens, which I have referred to three species of *Betulites;* four to *Betulites populifolius* Lesq., two to *Betulites rugosus* Lesq., and the remainder to nine different varieties of *Betulites Westii.* The leaves are, for the most part, very well

preserved. The venation shows marked similarity to our modern *Betula*. The great difficulty met with in classifying these leaves is to distinguish one variety of *Betulites Westii* from some one or from several of the other fourteen varieties, which Lesquereux has, I believe unnecessarily, recognized in this species. A distinguishing characteristic of *Betulites Westii* is the long, slender petiole, which unfortunately is absent in nearly all of our specimens. The bifid stipule, with lanceolate pointed lobes, which Lesquereux says is rarely preserved, is also lacking, another mark of distinction. I have found also a close similarity between some of the *Betulites* and the *Viburnums*, as figured in the Flora of the Dakota Group, such, for example, as *Betulites populifolius* and *Viburnum Lesquereuxii* var. *cordifolium*. One specimen, which seemed to fit each genus equally well, was referred to *Betulites* on account of the glandular tipped teeth, which seemed to be more characteristic of our modern *Betula* than of our *Viburnums*.

9. **Betulites populifolius** Lesquereux.

Betulites populifolius LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 64, Pl. 6, figs. 1, 2.

Description: The leaf is 6 cm. long and about the same width at a distance of 2 cm. from the base. The base is somewhat truncate-cuneate and the apex is obtusely pointed. The margin is distinctly dentate. The midrib is straight and thick. There are about ten pairs of secondaries, which are oblique, parallel, equidistant, and alternate, except the lowermost pair, which is opposite. Each secondary passes straight to a tooth in the margin. About two-thirds of the distance from the midrib each secondary sends off a branch from the lower side, which passes to a tooth in the margin. Only a portion of the petiole is present. There are four specimens, which I have referred to this species. Nos. 9 and 9*a* are parts of the same nodule and are therefore upper and lower surfaces of the same leaf. Nos. 9*b* and 9*c* also show the upper and lower surfaces of another leaf. One specimen (9*b*) shows glandular-tipped leaves. This is true of our modern *Betula populifolia*. These leaves resemble some of our modern *Viburnums*. While some of our *Viburnums* show callous-tipped teeth, I have found none to show the glandular tips. This fact has influenced me in referring these leaves to *Betulites*.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 9, 9a, 9b, 9c*).

10. **Betulites Westii** var. **latifolius** Lesquereux.

Betulites Westii var. *latifolius* LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 61, Pl. 4, figs. 9–11.

Description: There are several specimens of these leaves, ranging from 4.5 cm. to 6.5 cm. in length and from 4 cm. to 4.5 cm. in width. They are ovate, bluntly pointed, denticulate, subtruncate, or broadly cuneate at the base. They are regularly pinnate. The median nerve is straight. The secondaries are equidistant, parallel, and craspedodrome; the lowermost pair is suprabasilar and opposite. Petioles are absent. These specimens are for the most part very well preserved.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 13, 13a, 13b, 13c, 13d*). No. *13c* is from the same locality, but of the Chas. Sternberg Collection (C. M., Accession No. 4799).

11. **Betulites Westii** var. **rotundatus** Lesquereux.

Betulites Westii var. *rotundatus* LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 61, Pl. 4, figs. 12–16.

Description: The leaves are about 3 cm. in diameter both ways. They are almost round, with a rounded blunt apex and a truncate base. The margin is subentire or indistinctly denticulate. The nervation is pinnate, craspedodrome. The primary nerves are straight. There are about six pairs of secondary nerves which are opposite, parallel, equidistant; the lowermost pair being suprabasilar. The petioles of several are about 15 mm. long, enlarged at the base, and evidently stipulate.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 17, 17a, 17b, 17c, 17d, 17e*).

12. **Betulites Westii** var. **oblongus** Lesquereux.

Betulites Westii var. *oblongus* LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 61, Pl. 4, figs. 17–19.

Description: The leaf is 4 cm. long and 3.4 cm. broad. It is oblong-ovate with truncate base, rounded apex, and finely denticulate margin. The venation is the characteristic venation of all the specimens of *Betulites Westii.* The leaf is a little larger than Lesquereux represents it, but it seems to fit *oblongus* better than any other variety of *Betulites Westii.*

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 19, 19a*).

13. **Betulites Westii** var. **subintegrifolius** Lesquereux.

Betulites Westii var. *subintegrifolius* LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 61, Pl. 4, figs. 1–4.

Description: The leaves are about 4 cm. long and from 2.5 to 3 cm. broad. They are oval, obtuse, cordate, with entire margins. The venation is distinctly that of *Betulites Westii.* The leaf resembles fig. 1, Lesq., *op. cit.*, with the exception that it is longer in proportion to its width than the figure indicates. These two specimens, which are impressions of the same leaf, are more elliptical in outline than any figures of *Betulites Westii* shown by Lesquereux. I do not think that a new species or even variety should be made of this leaf, and have, therefore, referred it to *subintegrifolius.*

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 20, 20a*).

14. **Betulites Westii** var. **multinervis** Lesquereux.

Betulites Westii var. *multinervis* LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 62, Pl. 4, figs. 20–22.

Description: The leaves are about 2.5 cm. long and about 2 cm. wide. They are oval, obtuse, truncate, distinctly denticulate, with eight or nine pairs of secondary nerves. The venation is distinctly that of *Betulites Westii.*

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 22*). *No. 22a* is from the U. S. National Museum (C. M., Accession No. 4799).

15. **Betulites Westii** var. **rhomboidalis** Lesquereux.

Betulites Westii var. *rhomboidalis* LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 62, Pl. 5, figs. 6, 7.

Description: The leaf is about 6.5 cm. long and the same width near the middle. It is rhomboidal, with blunt apex and broadly cuneate base. The veining is not very distinct, but there are evidently four or five pairs of secondaries which are nearly or quite opposite, parallel, and craspedodrome. The areolation is very distinct in some portions, this being a characteristic of *Betulites.*

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 31*).

16. **Betulites Westii** var. **obtusus** Lesquereux.

Betulites Westii var. *obtusus* LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 61, Pl. 4, figs. 5–8.

Description: The leaf is 3.6 cm. long and 3.2 cm. in width. It is oblong-oval and rounded at the apex. The margin is minutely denticulate, this character showing very distinctly near the apex. There are six pairs of secondaries. The veining is distinctly that of *Betulites.*

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 45*). *No. 45a* is one of the collection from the U. S. National Museum (C. M., Accession No. 4799).

17. **Betulites Westii** var. **quadratifolius** Lesquereux.

Betulites Westii var. *quadratifolius* LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 62, Pl. 5, fig. 9.

Description: The leaf is about 4.5 cm. long and 5 cm. wide. There are five pairs of secondaries. The lowermost pair curves downward in reaching the midrib more than any of those figured under *Betulites* by Lesquereux *op. cit.* The veining, however, and the general appearance of the leaf is distinctly that of *Betulites.*

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 46*).

18. **Betulites Westii** var. **inæquilateralis** Lesquereux.

Betulites Westii var. *inæquilateralis* LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 62, Pl. 5, figs. 10–13.

Description: The leaf is about 2.5 cm. long and 2.5 cm. wide. It is a well-preserved leaf, showing the typical venation of *Betulites Westii*. It is somewhat inequilateral, which is a characteristic of the variety.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Chas. Sternberg Collection, U. S. National Museum (C. M., Accession No. 4799). Carnegie Museum, Pittsburgh, Pa. (*No. 67*).

19. **Betulites rugosus** Lesquereux.

Betulites rugosus LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 65, Pl. 6, figs. 3–5.

Description: We have both the upper and the lower surface of the same leaf. Only a portion of the petiole is present, and the apex is not perfect. The leaf is about 5 cm. in diameter both ways, with a truncate base slightly deflexed to the petiole. The nervation is strong. The primary is slightly curved. There are about eight pairs of secondaries; the lowermost is opposite and ramose, the others are alternate, equidistant, and parallel. The margin is denticulate. The leaf is slightly inequilateral. In this respect it resembles Lesquereux's fig. 3, *op. cit.* *Nos. 18* and *18a* are halves of the same nodule.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 18, 18a*).

URTICALES.

Family MORACEÆ.

Genus FICUS.

20. **Ficus macrophylla** Lesquereux.

Ficus macrophylla LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 76, Pl. 11, fig. 1.

Description: Our specimen resembles the one described and figured

by Lesquereux, *op. cit.*, except in the base. The base and apex of Lesquereux's leaf were lacking. He assumes, as is shown by the figure, that the base is cuneate. The upper part of our leaf is lacking. The lower part, probably about half of it, is almost perfect, except very near the petiole. The base is narrowed, but has the same width for some distance, and has the appearance of being somewhat auricled or heart-shaped at the petiole. Lesquereux may have been mistaken in assuming that the base of his leaf was sharp pointed; if not, our leaf does not belong to the same species. Our specimen does not resemble any other species of *Ficus* with which I have compared it, and does resemble that of *Ficus macrophylla* Lesq. so closely in venation that I have decided to refer it to that species regardless of the difference in the base.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 10*).

21. **Ficus daphnogenoides** (Heer) Berry.

Protcoides daphnogenoides HEER, Phyllites crétacées du Nebraska, 1866, p. 17, Pl. 4, figs. 7, 8 (not seen); LESQUEREUX, American Journal of Science and Arts (second series), XLVI, 1868, p. 99; Cretaceous Flora, Report of the Geological Survey of the Territories, VI, 1874, p. 85, Pl. 15, figs. 1, 2; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 90 (reference only).

NEWBERRY, The Flora of the Amboy Clays, U. S. Geological Survey, Monograph XXVII, 1895, p. 72, Pl. 17, figs. 8, 9; Pl. 32, figs. 11, 13, 14; Pl. 33, fig. 3, and Pl. 41, fig. 15.

HOLLICK, The Cretaceous Flora of Southern N. Y. and New England, U. S. Geological Survey, Monograph L, 1907, p. 59, Pl. 12, figs. 1–5.

Ficus proteoides LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 77, Pl. 12, fig. 2.

Ficus daphnogenoides (HEER) BERRY, A Ficus Confused with Proteoides. Bulletin of the Torrey Botanical Club, XXXII, June, 1905, pp. 327–330, Pl. 21; *Ibid.*, XXXIV, 1907, p. 194, Pl. 11, fig. 10; The Flora of the Raritan Formation, U. S. Geological Survey of N. J., Bulletin 3, 1911, p. 122, Pl. 12, fig. 4.

Description: There are three specimens which I have referred to this species. Berry, "The Flora of the Raritan Formation," p. 122, gives Heer's original description of *Protcoides daphnogenoides.* In his own description, page 123, he gives the following: "This species has been found to be quite variable in size, ranging in length from

11 cm. to 22 cm. and in breadth from 1.9 cm. to 3.7 cm. It is usually widest in the lower half of the leaf, although sometimes the base is quite narrow and the widest part is toward the middle. In all unequivocal material the upper half of the leaf is narrow, and is produced as a long, slender, recurved tip, which is one of the characteristic features of the species." Our specimens are about 15 cm. long and between 2 and 3 cm. wide.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 15, 15a, 15b*).

22. **Ficus inæqualis** Lesquereux.

Ficus inæqualis LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 82, Pl. 49, figs. 6–8, and Pl. 50, fig. 3.

Description: A small portion of both apex and base is broken off. The entire leaf is about 10 cm. long and 4.5 cm. wide at its widest point, which is a little below the middle. In shape it is very much like fig. 3, Pl. 50, Lesq., *op. cit.* The sides are unequal, the one being 2.5 cm. and the other 2 cm. wide. The veining corresponds to the description, *op. cit.* The leaf resembles also *Magnolia speciosa.* The veining does not seem so distinct as it is in most of our specimens of *Magnolia,* and the leaf also is a little smoother. The leaf may be *Magnolia speciosa,* but the weight of evidence is in favor of the species to which I have referred it.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 37*).

Family URTICACEÆ.

Genus ASPIDIOPHYLLUM.

23. **Aspidiophyllum trilobatum** Lesquereux.

Aspidiophyllum trilobatum LESQUEREUX, U. S. Geological and Geographical Survey of Colorado etc., by Hayden, 1874, p. 361, Pl. 2, figs. 1, 2; Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 87, Pl. 12, fig. 1, and Pl. 13, figs. 1–5, and Pl. 14, fig. 1; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 212. (Gives name and reference only.)

Description: Our specimen shows almost a perfect leaf, the margin in places being a little indefinite. It is about 15 cm. wide and about 11 cm. long. The venation is almost perfect and is very similar to that shown on Pl. 2, fig. 1, of Hayden's Report, *op. cit.*, and Pl. 3, fig. 1, of The Cretaceous and Tertiary Floras, *op. cit.* Indeed, the two figures looked so much like our specimen that I at first thought they might have been made from our fossil, which, too, is of the Chas. Sternberg collection and identified by Lesquereux. On close comparison the size and veining are seen to vary slightly.

Occurrence: Fort Harker, Kansas, Dakota Sandstone (Cretaceous). Chas. Sternberg Collection, Accession No. 4799, Carnegie Museum, Pittsburgh, Pa. (*No. 58*).

Remarks: No. 58a is a fragment of a large leaf from Ellsworth County, Kansas, in the Bayet Collection, which resembles in venation *Platanus primæva* Lesquereux and our modern *Platanus occidentalis* so closely that I, at first, thought it should be referred to *Platanus primæva,* but on close comparison with *Aspidiophyllum trilobatum* I have decided that it shows closer relationship to the latter. There certainly is a close interrelation of these two genera and they probably have had a common ancestor. (See discussion under Genus *Platanus.*)

RANUNCULALES.

Family MAGNOLIACEÆ.

Genus MAGNOLIA.

24. **Magnolia alternans** Heer.

Magnolia alternans HEER, Phyllites Crétacées du Nebraska, 1866, p. 20, Pl. 3, figs. 2–4; Pl. 4, figs. 1, 2; Flora Fossilis Arctica, III, Abth. 2, 1874, p. 116. Pl. 33, figs. 5 and 6, and Pl. 34, fig. 4; *Ibid.*, VI, Abth. 2, 1882, p. 91, Pl. 21. fig. 2, and Pl. 46, fig. 21 (not seen).

LESQUEREUX, American Journal of Science and Arts (second series), XLVI, 1868, p. 100; Cretaceous Flora, Report of the Geological Survey of the Territories, VI, 1874, p. 92, Pl. 18, fig. 4; Illustrations of Cretaceous and Tertiary Plants, U. S. Geological Survey of the Territories, 1878, Pl. 5, fig. 6; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 201, Pl. 34, fig. 11.

SMITH, Geology Coastal Plain in Alabama, 1894, p. 348.

POLLARD, Transactions of N. Y. Academy of Science, XIII, 1894, p. 181.

NEWBERRY, The Flora of the Amboy Clays, U. S. Geological Survey, Monograph XXVI, 1895, p. 73, Pl. 55, figs. 1, 2, 4, 6; The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, p. 94, Pl. 5, fig. 6.

HOLLICK, The Cretaceous Flora of Southern N. Y. and New England, U. S. Geological Survey, Monograph L, 1907, p. 67.

BERRY, The Flora of the Raritan Formation, Geological Survey of N. J., Bulletin 3, 1911, p. 130, Pl. 15, fig. 1.

Description: Leaf thick, ovate-oblong, about 9 cm. long and 4.7 cm. wide, entire, tapering to the petiole. Apex (broken) apparently abruptly acute. Petiole curved, about 3.2 cm. long. Midvein straight, prominent. Secondaries slender, about ten pairs, alternate, equidistant, camptodrome, branching from the midrib at an angle of about 45°.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 1*).

25. **Magnolia obtusata** Heer.

Magnolia obtusata HEER, Flora Fossilis Arctica, VI, Abth. 2, 1882, p. 90, Pl. 15, fig. 12, and Pl. 21, fig. 3 (not seen).

LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 201, Pl. 60, figs. 5, 6.

Description: Leaf coriaceous, obovate, obtuse, gradually narrowed to the petiole, which is nearly 2 cm. long; margin entire; secondaries simple, curved, camptodrome about five pairs (not very distinct toward the apex). The leaf is about 7 cm. long and 4.5 cm. wide at a point about 1.5 cm. from the apex, which is blunt and rounded. The leaf resembles in shape and veining that of Lesquereux shown in Pl. 60, fig. 6, *op. cit.* The petiole is somewhat shorter and the leaf seems to be a little shorter and broader than that of Lesquereux.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 28*).

26. **Magnolia speciosa** Heer.

Magnolia speciosa HEER, LESQUEREUX, The Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 72; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 202, Pl. 60, figs. 3, 4.

HOLLICK, Bulletin Torrey Club, XXI, 1894, p. 60, Pl. 178, fig. 5; Bulletin Geological Society America, VII, 1895, p. 13; The Cretaceous Floras of Southern N. Y. and New England, U. S. Geological Survey, Monograph L, 1906, p. 64, Pl. 19, figs. 1–4.

KNOWLTON, 21st Annual Report U. S. Geological Survey, Pt. 7, 1901, p. 318.

BERRY, Bulletin Torrey Botanical Club, XXXII, 1905, p. 46, Pl. 2, figs. 4, 5; The Flora of the Raritan Formation, Geological Survey of N. J., Bulletin 3, 1911, p. 129, Pl. 14, fig. 3.

Description: "Magnolia foliis maximis, coriaciis, ovato-ellipticis, apice longe attenuatis, valde acuminatis, basi in petiolum validum attenuatis, nervo primario crasso, nervis secundariis valde curvatis, camptodromis." Heer, 1869. (From Berry, Flora Raritan Formation, *op. cit.*). Our specimen shows, almost in perfect condition, the lower half of the leaf, the apical end being broken. The base, veining, and shape of the lower half very closely resemble *Magnolia speciosa.* The attenuated apex of the leaf is one of the marked features of the leaf, but this mark of identification is wanting in our specimen.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 36*).

Family MENISPERMACEÆ.

Genus MENISPERMITES.

27. **Menispermites obtusilobus** Lesquereux.

Dombeyopsis obtusiloba LESQUEREUX, American Journal of Science and Arts (second series), XLVI, 1868, p. 100.

Menispermites obtusilobus LESQUEREUX, Cretaceous Flora, U. S. Geological Survey of the Territories, VI, 1874, p. 94, Pl. 25, figs. 1, 2, and Pl. 26, fig. 3; Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 78, Pl. 15, fig. 4; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 196. (Name and reference only.)

Menispermites obtusiloba var. (?) LESQUEREUX, Cretaceous Flora, U. S. Geological Survey of the Territories, VI, 1874, p. 95, Pl. 22, fig. 1.

Description: Our specimen is not perfect. It is crumpled and somewhat broken. It is from the U. S. National Museum, Leo. Lesquereux Collection, and was identified by Lesquereux as *Menispermites salincusis* Lesquereux. The impression was not completely exposed when it was identified by him. Some of the overlying stone has since been

removed, which shows the leaf to have a different outline, making it resemble more closely *Menispermites obtusilobus,* to which species I have referred it.

Occurrence: Salina, Kansas, Dakota Sandstone (Cretaceous). Leo. Lesquereux Collection, U. S. National Museum (C. M., Accession No. 4799), Carnegie Museum, Pittsburgh, Pa. (*No. 61*).

Family LAURACEÆ.

Genus SASSAFRAS.

There are seventeen specimens in the collection, which I have referred to seven species of this genus. Most of these species have been included in *Sassafras cretaceum* Newb. by Newberry in Later Extinct Floras of N. A., page 98, Pl. 6, figs. 1–4; Pl. 7, figs. 1–3; Pl. 8, figs. 1, 2.

Berry in his Notes on Sassafras, Botanical Gazette, XXXIV, Dec., 1902, pp. 426–450, has retained *Sassafras Mudgei* and *Sassafras cretaceum* (in part) in this genus. *Sassafras acutilobum* he has doubtfully referred to *Aralia. Sassafras harkerianum* and *S. obtusum* he refers to *Cissites;* while *Sassafras dissectum* and *S. mirabile* he has referred to *Platanus.*

I have not hesitated to refer them all to *Sassafras* except *Sassafras* (*Araliopsis*) *dissectum* and *S. mirabile,* both of which, as well as those referred to the same species by Lesquereux, seem to be more closely related to *Platanus* than to *Sassafras.*

28. **Sassafras acutilobum** Lesquereux.

Sassafras acutilobum LESQUEREUX, Cretaceous Flora, Report of the Geological Survey of the Territories, VI, 1874, p. 79, Pl. 14, figs. 1, 2; The Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 56, Pl. 5, figs. 1, 5.

NEWBERRY, The Flora of the Amboy Clays, U. S. Geological Survey, Monograph XXVI, 1895, p. 87, Pl. 25, figs. 1–10, and Pl. 26, figs. 2–6; The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, pp. 98, 99.

BERRY, Notes on Sassafras, Botanical Gazette, XXXIV, Dec., 1902, pp. 426–450; The Flora of the Raritan Formation, Geological Survey of N. J., Bulletin 3, 1911, p. 140, Pl. 18, fig. 2.

HOLLICK, Cretaceous Flora of Southern N. Y. and New England, U. S. Geological Survey, Monograph L, 1906, p. 77, Pl. 30, figs. 8, 9.

Description: Trilobate leaf about 15 cm. long from base to apex of center lobe, and about 15 cm. between apices of the lateral lobes. The lobes are conical, entire, and acute, the middle being somewhat longer and broader than the lateral. The sinuses are open and rounded, the margins forming an angle of about 90°. The base is decurrent to the petiole (broken). The lateral primaries branch from the midrib 2 cm. from the base. Their angle of divergence from the midrib is about 35°. The secondaries are camptodrome; the first pair originates about 3.5 cm. from the origin of the lateral primaries, extending to the sinuses of the leaf. The secondaries are connected by tertiaries, which form somewhat rectangular areolations.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 5*). A smaller very well-preserved specimen (*No. 5a*) from the same locality is of the Hambach Collection, U. S. National Museum (C. M., Accession No. 4799). Another specimen (*No. 5b*) is from Fort Harker, Kansas, Chas. Sternberg Collection, U. S. National Museum (C. M., Accession No. 4799).

29. **Sassafras Mudgei** Lesquereux.

Sassafras Mudgei LESQUEREUX, American Journal of Science and Arts (second series), 46, 1868, p. 99; Cretaceous Flora, U. S. Geological Survey of the Territories, VI, 1874, p. 78, Pl. 14, figs. 3–4 and Pl. 30, fig. 7; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 100 (reference only).

KNOWLTON, Bulletin U. S. Geological Survey No. 152, 1898 (gives synonyms).

NEWBERRY, The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, p. 98.

WARD, Nineteenth Annual Report U. S. Geological Survey, Part 2, 1899, p. 705, Pl. 170, figs. 4, 5, and Pl. 171, fig. 1.

Description: Our specimen shows the middle lobe and a small portion of each of the side lobes. There is no doubt about the identity of the specimen. It came from the U. S. National Museum by exchange and bore a label referring it to this species.

Occurrence: Salina, Kansas, Dakota Sandstone (Cretaceous). Accession No. 4799, Carnegie Museum, Pittsburgh, Pa. (*No. 60*).

30. **Sassafras dissectum** Lesquereux.

Sassafras (*Araliopsis*) *dissectum* LESQUEREUX, The Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 57; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, 101, Pl. 14, fig. 1.

Description: The leaf very closely resembles, in shape and veining, the figure shown in The Flora of the Dakota Group, *op. cit.* It is, however, smaller, being only about 14 cm. long and 16 cm. wide. The veining is so distinctly that of *S.* (*Araliopsis*) *dissectum* that it needs no description. Lesquereux, in the same description, says: "This form has not been seen among the numerous specimens of fossil plants examined from the Dakota Group until recently." Lesquereux's leaf, as well as this one, should probably be referred to *Platanus.*

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 43*). Former reports give its habitat as near Fort Harker, Kansas.

31. **Sassafras cretaceum** Newberry.

Sassafras cretaceum NEWBERRY, Annals New York Lyceum of Natural History, IX, Apr. 1868, p. 14; The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, p. 98, Pl. 6, figs. 1–4; Pl. 7, figs. 1–3, and Pl. 8, figs. 1, 2. (Synonyms given.)

LESQUEREUX, Illustrations of Cretaceous and Tertiary Plants, 1878, Pl. 6, figs. 1–4.

BERRY, Notes on Sassafras, Botanical Gazette, XXXIV, 1902, p. 444.

Description: "Leaves petiolate, decurrent at base, very smooth above, strongly nerved below; three-lobed; lobes entire and acute. The nervation is all strongly defined; the central nerve straight or nearly so; the lateral primary nerves springing from it at an angle of 30°; secondary nerves regularly arched till they approach the margin of the lobes, when they are abruptly curved and run together. From these the tertiary nerves are given off at a right angle, and from these the quaternary nerves spring at a similar angle, together forming a network of which the areoles are sub-quadrate." The above is Newberry's original description. There are five specimens which I have referred to this species. None of our leaves are complete, some being mere fragments. In general appearance and nervation they agree with Newberry's description.

Occurrence: All five specimens are from the Dakota Sandstone (Cretaceous). *No. 23* is from Ellsworth County, Kansas, Baron de Bayet Collection, Accession No. 2348; *Nos. 23a, 23b* are from Salina, Kansas, Accession No. 4799; *No. 23c,* locality not given, Accession No. 4799; *No. 63,* Fort Ellsworth, Kansas, Accession No. 4799. All in Carnegie Museum, Pittsburgh, Pa.

32. **Sassafras mirabile** Lesquereux.

Sassafras mirabile LESQUEREUX, Hayden's Report, 1872, p. 424; Cretaceous Flora, U. S. Geological Report of the Territories, VI, 1874, p. 80, Pl. 12, fig. 1; The Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 56; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, pp. 101, 102, 231.

NEWBERRY, The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, pp. 105, 106, Pl. 1, fig. 4.

BERRY, Notes on Sassafras, Botanical Gazette, XXXIV, Dec., 1902, pp. 426–450.

Description: Leaf coriaceous, three-lobed, about 12 cm. from apex of middle lobe to the base and about 12 cm. between the apices of the two outer lobes; base decurrent to a petiole about 2 cm. long. "The three primary nerves separate at a comparatively short distance above the decurrent base of the leaves, the lateral ones bearing outside in the lower part one or two thin marginal veinlets, which follow the borders in successive bows, joining the point of the lowest secondary veins; these are all simple, entering the points of obtuse teeth, which mark the borders of the lobes from the base to the point."—Lesquereux. The first pair of secondaries originating from the middle primary vein are formed about one-third of the distance from the base to the apex and extend to the sinuses. In outline the leaf resembles our modern *Platanus occidentalis.*

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 6*). Another specimen (*No. 6a*) is from Fort Harker, Kansas, Leo. Lesquereux Collection (C. M., Accession No. 4799).

33. **Sassafras Harkerianum** Lesquereux.

Sassafras Harkeriana LESQUEREUX, Hayden's Report, 1872, p. 425.

Sassafras Harkerianum LESQUEREUX, Cretaceous Flora, Report of the U. S.

Geological Survey of the Territories, VI, 1874, p. 81, Pl. 11, figs. 3, 4, and Pl. 27, fig. 2.—NEWBERRY, The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, p. 98.

Cissites harkerianus BERRY, Notes on Sassafras, Botanical Gazette, XXXIV, Dec., 1902, pp. 426–450.—LESQUEREUX, Cretaceous and Tertiary Floras, U. S. Geol. Surv. Terr., VIII, 1883, p. 67, Pl. 3, figs. 3, 4.

Description: Leaf coriaceous, three-lobed, with obtusely pointed, very short lobes; about 10 cm. from apex of central lobe to the abruptly pointed base, about 10 cm. between apices of the lateral lobes; petiole about 2 cm. long. The lateral primaries originate about 2 cm. from the base and form an angle of about 40° with the middle primary. A pair of secondaries branches from the petiole at the juncture of the leaf-blade and extends out along the margin of the leaf. The first pair of secondaries originates about 2.5 cm. above the juncture of the lateral primaries. They extend to the shallow sinuses. The secondaries are very strongly camptodrome. This species has been referred to *Sassafras cretaceum* Newb. by Newberry, *op. cit.* Berry and Lesquereux, *op. cit.*, refer it to *Cissites.*

Occurrence: Three well-preserved specimens of this species were studied, all from Ellsworth County, Kansas: Dakota Sandstone (Cretaceous). The specimen described above is of the Baron de Bayet Collection, Accession No. 2348; *Nos. 7a* and *7b* are from the U. S. National Museum (C. M., Accession No. 4799). All in Carnegie Museum, Pittsburgh, Pa.

34. **Sassafras obtusum** Lesquereux.

Sassafras obtusum LESQUEREUX, Hayden's Annual Report, 1871, p. 303; and 1872, p. 424; Cretaceous Flora, Report of the U. S. Geological Survey of the Territories, VI, 1874, p. 81, Pl. 13, figs. 2–4.

Sassafras cretaceum Newb., Later Extinct Flora, U. S. Geological Survey, Monograph XXXV, 1898, p. 98. (Synonyms given.)

Description: There are three specimens which I have referred to this species. *Nos. 62a* and *62b* are upper and lower surfaces of the same leaf. These are small and not complete, although the venation is very distinct. *No. 62* is a well preserved specimen, almost entire, except the petiole and a portion of the decurrent base. It is about 11 cm. long and of the same width. The venation is almost as distinct as that of a leaf from our modern Sassafras tree. Since there is so much confusion about the synonomy of the *Sassafras* species,

the only difficulty is to know to what species to refer it. Since it so closely resembles Lesquereux's figures, *op. cit.,* I have referred it to *S. obtusum.*

Occurrence: All three specimens were in the collection from the U. S. National Museum (C. M., Accession No. 4799). *No. 62* is from Ellsworth County, Kansas, the other two had no record of locality. All are of the Dakota Sandstone (Cretaceous). Carnegie Museum, Pittsburgh, Pa. (*Nos. 62, 62a, 62b*).

Genus LAURUS.

35. **Laurus proteæfolia** Lesquereux.

Laurus proteæfolia LESQUEREUX, Hayden's Annual Report, 1874, p. 342, Pl. 5, figs. 1, 2; The Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 52, Pl. 3, figs. 9, 10, and Pl. 16, fig. 6; The Flora of the Dakota group, U. S. Geological Survey, Monograph XVII, 1892, p. 92.

Description: Our specimen does not show the base and the apex. The leaf is apparently about 13 cm. long and 3.4 cm. wide below the middle. The leaf gradually narrows from below the middle upward to a long point. It narrows more rapidly to the base. The venation is not distinct. The median nerve is straight. The secondaries show faintly, but apparently are parallel, equidistant, and camptodrome. The original description of this leaf by Lesquereux in Hayden's Annual Report, 1874, fits our leaf very well. Our specimen resembles also those figured in the same report.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 42*). Former reports give its habitat as Fort Harker, Kansas.

ROSALES.

Family PLATANACEÆ.

Genus PLATANUS.

In classifying the specimens representing this genus, as well as some others of related genera, the relationship of such genera as *Platanus, Sassafras, Sterculia, Aralia, Liquidambar,* and a few others was very evident. Berry has discussed this relationship in his article,

"Aralia in American Paleobotany" (Botanical Gazette, XXXVI, Dec., 1903, pp. 421–428), also in his "Notes on Sassafras" (Botanical Gazette, XXXIV, Dec., 1902, pp. 426–450). It is also discussed by Lester F. Ward in his "Paleontological History of the Genus Platanus" (Proceedings of the U. S. National Museum, XI, 1888, pp. 39–42, Pls. 17–22).

Berry, in his "Notes on Sassafras," page 448, says: "The varying similarity and interrelation of the forms heretofore referred to *Sassafras, Aralia, Platanus, Aspidiophyllum, Cissites,* etc., clearly indicate that a change must soon be made in our conception of these genera; and this not only applies to *Sassafras,* but to various forms referred to the other genera as well, including also *Grewiopsis, Menispermites, Credneria,* etc."

Ward, *op. cit.,* in speaking of *Platanus, Aralia, Liquidambar, Sassafras, Liriodendron,* and *Aspidiophyllum* of the Dakota Group, says: "It would, of course, be wrong to say that all these forms belong to *Platanus;* but to predict that they will one day be recognized as interrelated, and as representing the remote ancestry of the plane and the sycamore, can, in the light of our present knowledge, scarcely be considered rash." Ward believes that all those leaves with a basal lobe like *Aralia digitata* should be referred to the *Platanaceæ* and suggests a new genus called *Protoplatanus,* or some other name indicative of their ancestral character. (Ward, Bulletin 37, U. S. Geological Survey, 1887, p. 63, under his discussion of *Aralia digitata* Ward.)

Such a difference in the lobing, venation, and margin exists in our modern *Sassafras* and *Platanus,* that, if strictly observed and adhered to, a revision of these two genera would likely take place. There are also differences in the venation of *Platanus* and *Sassafras,* on the one hand, from the allied genera of *Aralia, Sterculia, Cissites,* etc., on the other hand, which, if accurately observed and strictly adhered to, would, no doubt, place some fossil leaves, which have been referred to these latter genera, in either *Platanus* or *Sassafras,* more particularly in *Platanus.*

One of the differences referred to is in the branching of the primary veins at the base of the leaf, particularly in the five-lobed type. *Platanus* and *Sassafras* are palmately three-veined. Each of the two lateral primaries and the central one, which may be called the midrib, go to lobes in the lobed form of the leaf. If the *Platanus* or *Sassafras* leaf has five lobes, the veins extending into the two lower-

most lobes are branches from the two lateral primary veins and are therefore secondary veins. This branching of the primary veins is different in the other allied genera of the *Araliaceæ, Sterculiaceæ, Menispermaceæ, Vitaceæ,* and *Hamamelidaceæ* (*Liquidambar*). These are all, with very few exceptions, if at all palmately veined, of the palmately five-veined type. This is also evident in the leaves not lobed. In the five-lobed leaves of these last-named genera the veins running to the two lowermost lobes are primary veins, or, if they are secondaries, branching from the two upper lateral primaries, the origin is always very close to the midrib.

The data from my own observations are as follows:

a. Sterculiaceæ.—The leaves of thirty-one species were examined. In thirty of these the leaves were of the palmately five-veined form, or showed a very strong tendency toward it, while only one species showed three palmate veins, and this one showed no tendency to lobing.

b. Araliaceæ.—Out of sixteen species examined, the leaves of fourteen were of the palmately five-veined form; one with three veins, but no tendency toward lobing; the other one, *Panax trifolia,* shows many of the leaflets to be divided into four and five smaller leaflets, and in each case they are palmately veined, even those leaflets with only three smaller leaflets showing the five palmate veins.

c. Vitaceæ.—Out of twenty-seven species examined, the leaves of twenty-three species show the palmately five-veined form. A few of these have a tendency to form seven lobes; in this case the veins running to the two lowermost lobes are secondary veins. One species showed three veins springing from the base of the leaf, but in this case the leaf was a pinnately compound leaf. In one species (*Cissus repens*) the two lowermost veins come from the two lateral primaries, but originate very close to the midrib. In the remaining two species there are three veins, with but little, if any, tendency for others to branch from them; if so, they branch very close to the midrib.

d. Menispermaceæ.—In this family eleven species were examined, and all leaves showed the five—or more—palmate arrangement of the veins.

e. Hamamelidaceæ.—Sixteen *Liquidambar* leaves, all of one species, were examined. Of these twelve were palmately five-veined and five-lobed, three were palmately three-veined and three-lobed (with no

evidence of forming five lobes), and one was palmately five-veined but seven-lobed, the veins running to these two extra lobes being secondary veins. The three-lobed leaves have a tendency to form the five palmate veins, as the two lowermost veins were present, but rather delicate.

f. Platanaceæ.—Seven species of *Platanus* were examined, and all leaves were of the three-palmate-veined form. In the five-lobed leaves the veins extending to the two lowermost lateral lobes are always secondary veins, branching from the two lateral primary veins at some distance from the midrib. One species, *Platanus Wrightii* Watson, resembles very closely *Sterculia mucronata* and *Sterculia Snowii,* as figured by Lesquereux, "Flora of the Dakota Group," Pl. 30, figs. 1, 2, 5, even in the fact that the margin of the lobes shows little, if any, tendency to serration at the time of blooming. I did not have leaves of these species at the fruiting period. The leaves, however, were large and appeared nearly mature. One species, *P. Lindeniana,* showed only three-lobed leaves at the blooming period. These leaves were decurrent a distance of from 0.5–1.0 cm. on the inner face of the petiole. In several the base was indeed almost peltate.

g. Lauraceæ.—No *Sassafras* leaves that I have seen are palmately five-veined. The five-lobed leaves are traversed by secondary veins originating from the two lateral primaries at some distance from the midrib, as is the case with *Platanus,* but usually even farther from the midrib than in *Platanus.* According to Sinnott and Bailey (American Journal of Botany, Investigations on the Phylogeny of the Angiosperms, II, 1915, pp. 1–22, Pls. i–iv), *Sassafras* and *Platanus* would probably have the trilacunar type of node, and *Aralia, Sterculia, Cissites, Menispermum,* and *Liquidambar* would have the trilacunar type, or by amplification the multilacunar type. It seems to me that these palmately three-veined and palmately five-veined methods of venation might be very useful in separating *Platanus* and *Sassafras* on the one hand from the other allied genera on the other hand, and that differences, as pointed out by other investigators, particularly by Berry, may be used in separating the genera from each other. Many of the species of *Platanus* have been reduced to synonymy (see Knowlton, Bulletin U. S. Geological Survey 152, 1898, pp. 168, 169). Lesquereux, in the "Flora of the Dakota Group," p. 72, says: "Indeed

comparing the leaves of *Platanus primæva* of the Dakota Group with those of *Platanus Haydenii* of the Laramie, those of *Platanus Guillelmæ* of the Miocene, those of *Platanus appendiculata* of the Auriferous gravel deposits of the old Pliocene of California, and those of the living *Platanus occidentalis,* one sees the original type so clearly and distinctly preserved, that, overlooking the great differences of age, it would be difficult to separate these leaves into different species."

36. **Platanus primæva** Lesquereux.

Platanus primæva LESQUEREUX, Cretaceous Flora, Report of the Geological Survey of the Territories, VI, 1874. p. 69, Pl. 7, fig. 2, and Pl. 26, fig. 2; Geological and Natural History Survey of Minn., III, Pt. I, p. 14, 1885–1892; Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 72, Pl. 8, figs. 7–8b, and Pl. 10, fig. 1.

WARD, The Paleontological History of the Genus Platanus, Proceedings U. S. National Museum, XI, 1888, p. 39, Pl. 17–22.

Description: Our specimen is about 13 cm. long by about 15 cm. wide between the two lateral lobes. The leaf resembles *Platanus primæva* more closely than the other species. It differs, however, in that the base is more cuneate than truncate, resembling in this respect more nearly *Platanus primæva* var. *grandidenta.* The terminal lobe shows very little, if any, dentation. The leaf resembles in general outline a young leaf of our modern *Platanus.* The leaf does not look exactly like any figure of *Platanus* with which I have compared it, but since our modern *Platanus* leaves vary so much, I do not think a separate species or variety should be made for this specimen.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 48*).

37. **Platanus cissitifolia** Gress, sp. nov. (Plate XV, figs. 3 and 4.)

A specimen which came from the U. S. National Museum bore a label "*Cissites obtusus* Lesq., Lancaster County, Va.," this being the only specimen in the collection not from the Dakota Group of the Western United States. The matrix carrying the impression resembles that of the other fossils so closely in composition that I am inclined to think that there has been a mistake in naming the locality from which it has come. The impression of the leaf in this fossil

was not completely exposed. On removing some of the overlying stone, it was found to be a five-lobed leaf very different in outline from what it appeared to be before the removal of this overlying stone. It somewhat resembles *Cissites,* but does not fit any described species, with which I have been able to compare it. It resembles more closely than any other species *Cissites ingens* var. *parvifolia* Lesq. (Flora of the Dakota Group, 1892, Pl. 57, fig. 3), but differs in the branching of the primaries at the base of the leaf, also in its more cuneate base and lobed or toothed margin. It resembles so closely in outline and venation our modern *Platanus occidentalis* that I have named it *Platanus cissitifolius.* The leaf is five-lobed, nearly 6 cm. long, and about the same width between the apices of the two uppermost lateral lobes. It is palmately three-veined; the two lateral primary veins originate about 5 mm. from the base of the leaf and extend into the two uppermost lateral lobes. Each lateral primary vein sends out a branch from its lower side about 1.5 cm. from the base of the leaf, which extends to the lowermost lateral lobe. The margin is sinuate or toothed. The tertiary venation resembles very closely that of our modern *Platanus occidentalis.*

Family ROSACEÆ.

Genus PYRUS.

38. **Pyrus cretacea** Newberry.

Pyrus cretacea NEWBERRY, Annals N. Y. Lyceum Natural History, IX, April, 1868, p. 12; The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, p. 110, Pl. 1, fig. 7.

LESQUEREUX, Illustrations of Cretaceous and Tertiary Plants, 1878, Pl. 2, fig. 7; The Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 86; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 144 (name and reference only).

Description: The leaf is very small, being about 1.5 cm. long and of the same width. It fits very closely Newberry's description, which follows: "Leaves petioled, small, roundish, oval or elliptical, often slightly emarginate, entire or finely serrate; medial nerve strong below, rapidly diminishing toward the summit; lateral nerves four or five pairs, with intermediate smaller ones, diverging from the midrib at unequal angles, curved toward the summit, where they anastomose in a series of arches parallel with the margins; tertiary nerves forming a network of which the areoles are somewhat elongated."

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 44*). Former Report, Dakota Group, Smoky Hill, Kansas.

Family LEGUMINOSÆ.

Genus HYMENÆA.

39. **Hymenæa dakotana** Lesquereux.

Hymenæa dakotana LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 145, Pl. 55, figs. 2, 3, Pl. 56, figs. 1, 2, and Pl. 62, fig. 2.

NEWBERRY, The Flora of the Amboy Clays, U. S. Geological Survey, Monograph XXVI, 1896, p. 90, Pl. 41, fig. 14.

BERRY, Annual Report of the State Geologist (N. J.), 1905, pp. 138, 139, Pl. 22, figs. 1, 2; The Flora of the Raritan Formation, Geological Survey of N. J., Bulletin 3, 1911, p. 165.

HOLLICK, The Cretaceous Flora of Southern N. Y. and New England, U. S. Geological Survey, Monograph L, 1907, p. 83, Pl. 32, figs. 5–7.

Description: The base and apex of one leaf are broken. The petiole of the other one is wanting and the apex is bent a little, which gives it somewhat the appearance of being emarginate, as are the leaves of *Leguminosites hymenophyllus*, which, indeed, the specimen resembles. The leaves are oblong or elliptical, narrowed to the base and apex, entire. Only a few of the secondaries can be indistinctly seen. They are joined to the midvein at an angle of about 45°. They curve in passing to the borders and are camptodrome. The midrib is heavy at the base, but tapers rapidly, becoming very thin toward the apex.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 33*).

Genus PALÆOCASSIA.

40. **Palæocassia laurinea** Lesquereux.

Palæocassia laurinea LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 147, Pl. 64, fig. 12.

Description: Leaflet between 5 and 6 cm. long (apex broken), about 1.5 cm. broad a little below the middle, lanceolate, narrowing to both

ends, slightly inequilateral and curved to one side. Midrib curved; secondaries parallel, opposite or nearly so, arched and camptodrome; margin entire; petiole not shown.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 14*).

GERANIALES.

Family EUPHORBIACEÆ.

Genus DAPHNOPHYLLUM.

41. **Daphnophyllum dakotense** Lesquereux.

Daphnophyllum dakotense LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 99, Pl. 51, figs. 1–4, and Pl. 52, fig. 1.

Description: The description, which Lesquereux, *op. cit.*, gives of his leaves, fits our specimen very well, with the exception that the secondaries are opposite. The lowermost secondaries of our leaf do not show very distinctly, but they do not appear to be opposite. Pl. 52, fig. 1, Lesquereux, *op. cit.*, shows the secondaries alternate with the exception of the lowermost pair. I found with the specimen two loose labels in different handwriting; the one contained the name *D. angustifolium*, the other one *D. dakotense*. I think our specimen, which is a split-open nodule, showing both upper and lower surfaces, agrees more closely with the latter, which name I have given to it.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 38, 38a*).

SAPINDALES.

Family CELASTRACEÆ.

Genus CELASTROPHYLLUM.

42. **Celastrophyllum cretaceum** Lesquereux.

Celastrophyllum cretaceum LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 173, Pl. 38, figs. 12–14. NEWBERRY, The Flora of the Amboy Clays, U. S. Geological Survey, Monograph XXVI, 1896, p. 100, Pl. 42, fig. 13.

BERRY, The Flora of the Raritan Formation, Geological Survey of N. J., Bulletin 3, 1911, p. 177.

Description: "Leaves small, 2 cm. to 4 cm. in length by 0.9 cm. to 1.2 cm. in breadth, elliptical or oblong in outline. Apex obtusely rounded. Base narrowed, giving some of the leaves an almost spatulate outline. Texture thick, subcoriaceous. Margin entire throughout. Midrib comparatively stout. Secondaries slender, branching from the midrib at an angle of 30° to 40°, slightly curved, distant, parallel, often obsolete, camptodrome." Berry, *op. cit.* This description by Berry applies well to our specimen, which is 3.5 cm. long by 1 cm. wide.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 39*). A smaller specimen (*No. 39a*) is from the U. S. National Museum (C. M., Accession No. 4799).

RHAMNALES.

Family RHAMNACEÆ.

Genus RHAMNUS.

43. **Rhamnus inæquilateralis** Lesquereux.

Rhamnus inæquilateralis LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 170, Pl. 37, figs. 4–7.

Description: The leaf is about 7 cm. long and 2.5 cm. wide near the middle. It is entire, lanceolate, acuminate (apex broken), narrowed and decurring to the petiole (absent), inequilateral, curved to one side. The primary nerve is rather heavy below, but becomes narrow toward the apex. There are about six pairs of secondaries at an acute angle of divergence; curved somewhat in passing to the margin, opposite or subopposite, camptodrome, the lowermost pair is thin and very close to the margin.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 49*). Reported from Cliffwood Bluff, N. J., by Berry. Another specimen studied (*49a*) is from the Chas. Sternberg Collection (C. M., Accession No. 4799).

MALVALES.

Family STERCULIACEÆ.

Genus STERCULIA.

The leaves which I have referred to this genus show a close relationship to *Platanus,* particularly in the arrangement of the primary and secondary veins and in the lobing. (See discussion of *Platanus.*) *Sterculia mucronata* Lesquereux, as figured by Lesquereux in The "Flora of the Dakota Group," Pl. 30, figs. 1–4, and the several specimens, which I have referred to that species, all very closely resemble in outline, in branching of the primaries, and in lobing, the leaves of our modern *Platanus Wrightii* Watson. The lobing is also very similar to our modern *Liquidambar styraciflua,* but the branching of the primary veins differs.

44. **Sterculia Snowii** Lesquereux.

Sterculia Snowii LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 183, Pl. 30, fig. 5; Pl. 31, figs. 2, 3, and Pl. 32, and Pl. 33, figs. 1–4.

KNOWLTON, in HILL, American Journal of Science, L, 1895, p. 213.

HOLLICK, The Cretaceous Flora of Southern N. Y. and New England, U. S. Geological Survey, Monograph L, 1906, p. 94, Pl. 34, fig. 20.

Sterculia Drakei CUMMINS, Third Annual Report, Geological Survey Texas, 1891 (1892), p. 210, Text fig. 8.

Description: "Leaves long petioled, membranous or subcoriaceous, large, palmately two- to five-lobed; lobes entire, lanceolate, taper-pointed or acuminate, greatly diverging; primary nerves palmately three to five, from the top of the petiole, mostly simple, thick, percurrent; secondaries thin, oblique, straight, or slightly curved in traversing the blade, simply camptodrome. The largest leaves are more than 20 cm. long from the top of the petiole to the apex of the median lobe, and are quite as broad or broader between the apices of the lateral lobes; the petiole generally preserved is more than 20 cm. long, strong, inflated at the base. The divergence of the lobes averages 40°, the lateral ones being about at right angles to the median nerve, and generally curved backward; the primary nerves are thick, the secondaries thin, often obsolete, close, parallel, at an angle of divergence of 50°, curving quite near the borders, the curves forming a kind of thin, marginal nerve along them; the areolation is obsolete."—Lesquereux, *op. cit.*

The specimens examined fit almost exactly the above description by Lesquereux. They are of the five-lobed type, about 20 cm. long and 20 cm. broad. The petioles, however, are only between two and three centimeters long; they probably either have not been preserved or are broken off.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 4, 4a*). A third specimen (*4b*) is from Fort Harker, Kansas, Dakota Sandstone (Cretaceous). Chas. Sternberg Collection, from U. S. National Museum (C. M., Accession No. 4799).

45. **Sterculia aperta** Lesquereux.

Sterculia aperta LESQUEREUX, Cretaceous and Tertiary Floras, U. S. Geological Survey, Monograph VIII, 1883, p. 82, Pl. 10, figs. 2, 3; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 185, Pl. 22, fig. 1.

Sterculia obtusiloba LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 185. In the above citation Lesquereux says that *Sterculia obtusiloba* may be a variety of *Sterculia aperta*. *Sterculia obtusiloba* was first named *Aralia tripartita* by Lesquereux. See *Aralia tripartita* Lesquereux, Hayden's Annual Report, U. S. Geological and Geographical Survey of Colorado and adjacent Territories, 1874, p. 348, Pl. 1, fig. 1.

Description: Leaf palmately three-lobed and three-nerved from near the base; about 8 cm. long from base to apex and about 7 cm. broad between apices of the two outer lobes. The lobes vary from about 3.5 cm. to 5 cm. long and from 1 to 2 cm. wide, the middle being the longest and the narrowest. The lobes are entire, almost linear, abruptly rounded at the apex, and with obtuse sinuses. The surface is smooth, with a very slight trace of secondary veins. The base is apparently somewhat decurrent to the petiole, which is broken off.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 8*).

46. **Sterculia mucronata** Lesquereux.

Sterculia mucronata LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 182, Pl. 30, figs. 1–4.

Description: The specimen is about 7 cm. long from the top of the petiole to the apex of the middle lobe. It is probably from 8 to 10 cm. broad between the apices of the two upper lateral lobes (the one is broken off). The lowermost lateral lobes are rather short-pointed and recurved. It is palmately three-veined; the two lateral veins branch at a short distance from the petiole, each branch going to one of the lowermost lateral lobes. The leaf looks almost exactly like that represented in fig. 2, *op. cit.*

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 21*). A second specimen (*No. 21a*) is from Fort Harker, Kansas (C. M., Accession No. 4799).

Genus PROTOPHYLLUM.

This genus was established by Lesquereux to include some leaves which he had previously referred to *Credneria* or to *Pterospermites*. There are five specimens of these leaves in the collections studied: *Protophyllum Leconteanum* Lesquereux, *Protophyllum rugosum* Lesquereux, *Protophyllum Sternbergii* Lesquereux, and two other specimens which evidently belong to the genus *Protophyllum*, but which differ from any described species, with which I have been able to compare them. I, therefore, have given them the names *Protophyllum ovatum* and *Protophyllum viburnifolium*.

47. **Protophyllum ovatum** Gress, sp. nov. (Plate XIV, figs. 1 and 2.)

Description: The leaf is about 10 cm. long and 8 cm. wide a little below the middle. It is ovate or elliptical in outline, rather abruptly rounded to a truncate or somewhat heart-shaped base, and to a slightly acuminate apex. The margin is distinctly and coarsely toothed. There are ten or eleven pairs of craspedodrome secondaries, which spring from a midrib of medium thickness. The lowermost three or four pairs are crowded together and comparatively slender, branching from the midrib at a very large angle, nearly perpendicular. The remaining upper pairs are stronger, farther apart, and branch from the midrib at a more acute angle. The fourth and fifth pairs from the base send off about three branches from the lower side; fewer branches emerge from the secondaries toward the apex. Ter-

tiary venation is not visible. The venation resembles that of *Protophyllum querciforme* Hollick (Bulletin Torrey Botanical Club, XXII, May, 1895, p. 227, Pl. 237, fig. 1.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 51*).

48. **Protophyllum viburnifolium** Gress, sp. nov. (Plate XV, figs. 1 and 2.)

Description: The leaf is about 7 cm. long and 6 cm. wide. It is ovate in outline, with a short-pointed (?) apex (broken) and a very distinctly heart-shaped or peltate (?) base. The midrib is of medium thickness. There are six or seven pairs of secondaries, sub-opposite. The lowermost pair is very much branched on the lower side. The first branch, which is very thin, originates near the midrib and extends backward along the petiole. The second pair of secondaries emerges from the midrib close to the first pair and diverges at a much more acute angle than does the first pair. This pair is also much branched on the lower side. The distance between the origin of the second and the third pairs of secondaries is about twice the distance between the origin of the first two pairs. The remaining upper pairs of secondary veins are parallel and contain fewer branches than do the lower ones. The tertiary veining is simple and at right angles to the secondaries. The margin is apparently slightly undulate or toothed, but this character is not distinct. This leaf, as well as *Protophyllum ovatum,* resembles very much some of the Viburnums described and figured by Ward, Bulletin U. S. Geological Survey, No. 37, 1887. I think, however, that the nearly, if not altogether, peltate base of the smaller leaf and the arrangement of the secondary veins at the base of both leaves, particularly of the larger, show sufficiently close relationship to *Protophyllum* to justify referring them to that genus.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 50*).

49. **Protophyllum Leconteanum** (Lesquereux) Lesquereux.

Credneria Leconteana LESQUEREUX, American Journal of Science and Arts (series 2), XLVI, 1868, p. 98.

Protophyllum Leconteanum LESQUEREUX, Cretaceous Flora, Report of the U. S. Geological Survey of the Territories, VI, 1874, p. 103, Pl. 17, fig. 4, and Pl. 26, fig. 1; The Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 89. (Gives name and reference only); The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 187, Pl. 40, fig. 1.

Description: The leaf is almost perfect, except at a few places on the margin, particularly near the apex. The venation is very distinct. This is the only specimen in the collection from the Dakota Group in which we find portions of the leaf. About an inch of the lower end of the midrib with some branches is still in position. No attempt has been made as yet to study the cell structure of these remains, but probably sufficient tissue is present that by careful work something of the structure might be ascertained.

The fossil bears a label showing that it is one of a collection made by Chas. Sternberg and has been identified by Leo Lesquereux.

The leaf is about 10 cm. long and 10 cm. wide and fits Lesquereux's description and figures so well that it needs no description or discussion to refer it to *Protophyllum Leconteanum* Lesquereux.

Occurrence: Fort Harker, Kansas. Dr. Leconte collected his specimens about three miles northeast of Ft. Harker and near Brooksville, Kansas. *Credneria Leconteana* is described from Nebraska in American Journal of Science, *l. c.*

50. **Protophyllum Sternbergii** (Lesquereux) Lesquereux.

Pterospermites Sternbergii LESQUEREUX, U. S. Geological Survey of Montana, etc., by Hayden, 1872, p. 425.

Protophyllum Sternbergii LESQUEREUX, Cretaceous Flora, Report of the U. S. Geological Survey of the Territories, VI, 1874, p. 101, Pl. 16, fig. 1, and Pl. 17, fig. 2; Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 89. (Gives name and reference only); The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 189, Pl. 42, fig. 1.

Description: The leaf is about 10 cm. long by 9 cm. broad. The venation is distinctly that of *Protophyllum.* The base is broken so that the pelta, which Lesquereux says is the greatest distinguishing feature between *Sternbergii* and *Leconteanum,* can not be observed.

Judging by the other distinguishing features given by Lesquereux under his description of *Protophyllum Leconteanum,* I have decided that our specimen fits more closely that of *Protophyllum Sternbergii* than it does *Protophyllum Leconteanum.* The specimen was among fossils obtained by exchange from the U. S. National Museum, but bore no label.

Occurrence: Ellsworth County, Kansas (?), Dakota Sandstone (Cretaceous). U. S. National Museum by exchange, Accession No. 4799, Carnegie Museum, Pittsburgh, Pa. (*No. 56*).

51. **Protophyllum rugosum** (Lesquereux) Lesquereux.

Pterospermites rugosus LESQUEREUX, Hayden's Annual Report, 1872, p. 426.
Protophyllum rugosum LESQUEREUX, Cretaceous Flora, U. S. Geological Survey of the Territories, VI, 1874, p. 105, Pl. 17, figs. 1, 2, and Pl. 19, fig. 3; The Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 90; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 195. (Name and reference only.)

Description: Our specimen shows only a fragment of the leaf which gives pretty definitely the outline and veining of the base. It is only about 5 cm. broad near the base. The length, of course, can not be determined. The pelta and veining show rather distinctly, and evidently the leaf has been rightly determined by Leo Lesquereux, as is shown by the label found with the specimen.

Occurrence: Salina, Kansas, Dakota Sandstone (Cretaceous). Collected and identified by Leo Lesquereux, Accession No. 4799, Carnegie Museum, Pittsburgh, Pa. (*No. 57*).

Family TILIACEÆ.

Genus GREWIOPSIS.

This genus was established by Marquis Saporta. To it he referred leaves from the Paleocene of Sézanne, which resembled those of our modern genus *Grewia.* To this genus I have referred four specimens, all differing somewhat from each other, but not sufficiently so to make separate species. I have classified them as *Grewiopsis flabellata* (Lesq.) Knowlton.

52. **Grewiopsis flabellata** (Lesquereux) Knowlton.

Populites flabellata LESQUEREUX, American Journal of Science and Arts (second series), XLVI, 1868, p. 94.

Populites fagifolia LESQUEREUX, U. S. Geological Survey. Hayden, 1872, p. 442.

Grewiopsis flabellata (LESQUEREUX) KNOWLTON, Cretaceous Flora, Report of U. S. Geological Survey, VI, 1874, p. 97, Pl. 3, figs. 2, 4, and Pl. 24, fig. 3. KNOWLTON, *Grewiopsis Haydenii* Lesquereux = *Grewiopsis flabellata*. U. S. Geological Survey, Bulletin No. 152, 1898.

Description: The leaf is about 7 cm. long and 6 cm. wide. It is oval with an obtuse apex and a truncate or slightly cuneate base. The petiole is 1.5 cm. long (a portion is perhaps broken off). The midrib is straight, rather thick at the base, but tapering rapidly to the apex. There are about seven pairs of secondary veins, which are straight. The lowermost secondaries diverge somewhat as they approach the margin, while the uppermost are parallel. The secondaries are branched on the lower side and are craspedodrome. In outline the leaf resembles our modern poplar leaves.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Chas. Sternberg Collection, from the U. S. National Museum, Accession No. 4799, Carnegie Museum, Pittsburgh, Pa. (*No. 64*).

Remarks: There are three specimens in the Baron de Bayet Collection from Ellsworth County, Kansas, which I have also referred to the same species. *No. 64a* is larger than *No. 64*, being about 10 cm. long and 8 cm. wide. The venation is not distinct, but in outline and general appearance it resembles *Grewiopsis Haydenii* Lesquereux. I have hesitated somewhat to refer the other two specimens (*64b* and *64c*) to the same genus and species. The larger of these two (*64b*) shows serration very similar to that shown by Lesquereux in fig. 3, Pl. 24, Cretaceous Flora, *op. cit.* The venation, while not very distinct, is also very similar. These three specimens bear C. M., Accession No. 2348.

UMBELLALES.

Family ARALIACEÆ.

Genus ARALIA.

53. **Aralia Wellingtoniana** Lesquereux.

Aralia Wellingtoniana LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 131, Pl. 21, fig. 1; Pl. 21,

fig. 1, and Pl. 22, figs. 2, 3; SMITH, Geology Coastal Plain in Alabama, 1894, p. 348; NEWBERRY, The Flora of the Amboy Clays, U. S. Geological Survey, Monograph XXVI, 1896, p. 114, Pl. 26, fig. 1; BERRY, Aralia in American Paleobotany, Botanical Gazette, XXXVI, Dec., 1903, pp. 421–428; The Flora of the Raritan Formation, Geological Survey of N. J., Bulletin 3, 1911, p. 202, Pl. 25, fig. 7.

Description: "Leaves large, coriaceous, palmately three- or five-lobed, narrowed in an inward curve to a prolonged base; decurring to the petiole; lobes long, oblong-lanceolate, abruptly pointed, sharply equally dentate from above the base, the teeth turned outside or slightly upward, separated by shallow sinuses; primary nerves broad and flat; secondaries more or less oblique, slightly curving or nearly straight in passing to the borders, entering the teeth, craspedodrome, mostly simple; areolation distinctly reticulate, in irregularly quadrate or polygonal meshes. The leaves, which are 15 cm. to 16 cm. long, excluding the petiole, vary, of course, in width according to the number of lobes and their divergence from the median nerve, which in most of the specimens that I have seen averages 35°. The lobes are a little broader in the middle, slightly narrowing to the sinuses, 7 cm. to 10 cm. long, and from 2 cm. to 3 cm. broad at the middle."—Lesquereux, *op. cit.* The anastomosis is so marked that near the edge of the lobe the secondary veins might be thought to be camptodrome.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 2*).

54. **Aralia grœnlandica** Heer.

Aralia grœnlandica HEER, Flora Fossilis Arctica, Vol. VI, Abth. 2, 1882, p. 84, Pl. 38, fig. 3, Pl. 39, fig. 1, and Pl. 46, figs. 16, 17. (Not seen); Cretaceous Flora, U. S. Geological Survey of the Territories, VIII, 1883, p. 60; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 134, Pl. 54, figs. 1–3; NEWBERRY, The Flora of the Amboy Clays, U. S. Geological Survey, Monograph XXVI, 1896, p. 116, Pl. 28, fig. 4; BERRY, Aralia in American Paleobotany, Botanical Gazette, XXXVI, Dec., 1903, pp. 421–428; The Flora of the Raritan Formation, Geological Survey of N. J., Bulletin 3, 1911, p. 199. (Gives Heer's original description); HOLLICK, The Cretaceous Flora of Southern N. Y. and New England, U. S. Geological Survey, Monograph L, 1907, p. 98, Pl. 37, figs. 3–6.

Description: Leaf about 6.5 cm. long from base to apex, about 7 cm. in diameter between apices of the lateral lobes. Petiole stout and

about 2.1 cm. long. The leaf is trilobate, five-nerved; the lateral nerves diverge from the top of the petiole; the two lowermost nerves are thinner than those passing to the lobes. The base is truncate and rounded, declining to the petiole. The lobes are about equal, obtuse or apiculate, entire, separated by rather broad sinuses, which reach about half-way to the midvein.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 3, 3a*).

ERICALES.

Family ERICACEÆ.

Genus ANDROMEDA.

55. **Andromeda Parlatorii** Heer.

Andromeda Parlatorii HEER, Phyllites Crétacées du Nebraska, 1866, p. 18, Pl. 1, fig. 5; Flora Fossilis Arctica, III, Abth. 2, 1874, p. 112, Pl. 32, figs. 1, 2; *Ibid.*, VI, Abth. 2, 1882, p. 79, Pl. 21, figs. 1b., 11, and Pl. 42, fig. 4c. (Not available for reference); LESQUEREUX, Cretaceous Flora, U. S. Geological Survey of the Territories, VI, 1874, p. 88, Pl. 23, figs. 6, 7, and Pl. 28, fig. 15; The Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 60; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 115, Pl. 19, fig. 1, and Pl. 52, fig. 6; SMITH, Geology Coastal Plain in Alabama, 1894, p. 348; NEWBERRY, The Flora of the Amboy Clays, U. S. Geological Survey, Monograph XXVI, 1896, p. 120, Pl. 31, figs. 1–7, and Pl. 33, figs. 1, 2, 4, 5; HOLLICK, Annals N. Y. Academy of Science, XI, 1898, p. 420, Pl. 37, figs. 1–4; The Cretaceous Flora of Southern N. Y. and New England, U. S. Geological Survey, Monograph L, 1906, p. 101, Pl. 39, figs. 2–5; BERRY, Bulletin N. Y. Botanical Garden, III, 1903, p. 97, Pl. 50, figs. 1–4; Bulletin Torrey Botanical Club, XXXI, 1904, p. 79, Pl. 1, figs. 1, 2; *Ibid.*, XXXIII, 1906, p. 181; *Ibid.*, XXXIV, 1907, p. 203, Pl. 15, fig. 2; The Flora of the Raritan Formation, Geological Survey of New Jersey, Bulletin 3, 1911, p. 206.

Prunus Parlatorii (HEER) LESQUEREUX, American Journal of Science and Arts (second series), XLVI, 1868, p. 102.

Description: "A foliis lanceolatis, basi attenuatis, integerrimis, nervo medio valido, transversium striato, secundaris subtilissimis, angulo acuto egredientibus, camptodromis."—Heer, 1866. (From Berry, The Flora of the Raritan Formation.) The specimen is about 10 cm. in length, including the petiole, which is about 1 cm. long. It

is about 2.6 cm. wide at the widest point. The veining is indistinct. In outline our specimen resembles very closely fig. 4, Pl. 31, and fig. 2, Pl. 33, Newberry, *op. cit.*

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa.

Berry, in "The Flora of the Raritan Formation," says: "It is one of the commonest Cenomanian species occurring in Minnesota, Kansas, and Nebraska, in the west, and from Greenland to Alabama, in the east. It is as common in the overlying Magothy formation as it is in the Raritan, being recorded from Marthas Vineyard, New Jersey, Delaware, and Maryland. It also is present in the Bladen formation of North Carolina."

56. **Andromeda Pfaffiana** Heer.

Andromeda Pfaffiana HEER, Flora Fossilis Arctica, VI, Abth. 2, 1882, p. 79, Pl. 25, fig. 6, Pl. 38, figs. 5–7, and Pl. 44, fig. 12. (Not available for reference); LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 116, Pl. 18, figs. 7, 8, and Pl. 52, fig. 7.

Description: The leaf is 12.5 cm. long and 2.5 cm. wide. It is lanceolate, entire, gradually narrowing to the petiole; apex acuminate. The median nerve is not very prominent. The secondaries are thin, parallel, mostly opposite, curved up toward the border and down in reaching the midrib. The secondaries emerge from the midrib at an angle of 20°–25°. The petiole is apparently very short, or the leaf may be almost sessile.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 11, 11a*).

EBENALES.

Family EBENACEÆ.

Genus DIOSPYROS.

57. **Diospyros rotundifolia** Lesquereux.

Diospyros rotundifolia LESQUEREUX, Cretaceous Flora, Report of the Geological Survey of the Territories, VI, 1874, p. 89, Pl. 30, fig. 1; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 112, Pl. 17, figs. 8–11; HOLLICK, Bulletin Torrey Botanical Club, 21, 1894, p. 53, Pl. 179, fig. 2.

Myrsine borealis HEER, BERRY, The Flora of the Raritan Formation, Geological Survey of N. J., Bulletin 3, 1911, p. 208.

Description: The leaf does not fit the type given in Cretaceous Flora, Lesquereux, *l. c.* It does, however, come under his later description given in the Flora of the Dakota Group, *l. c.* There are two specimens of the leaf, one showing the upper and the other the lower surface. The leaf is 5 cm. long and 3.2 cm. broad near the middle; it is oval, obtuse, entire, tapering rather abruptly to the petiole. There are six pairs of secondaries, the lowermost indistinct and near the base. They branch from the midrib at an angle of 45°–50°, arched in traversing the blade, camptodrome; areolation indistinct.

Remark: Berry, *op. cit.*, gives *Diospyros rotundifolia,* as described by Hollick, *op. cit.,* as a synonym of *Myrsine borealis* Heer, and not the same as *Diospyros rotundifolia* Lesquereux.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). *Nos. 29* and *29a* are of the Baron de Bayet Collection (C. M., Accession No. 2348). *No. 29b* is from the U. S. National Museum (C. M., Accession No. 4799). All in Carnegie Museum, Pittsburgh, Pa.

58. **Diospyros Steenstrupi** Heer. (?)

Diospyros Steenstrupi HEER, Flora Fossilis Arctica, VII, 1883, 32, Pl. 64, fig. 1. (Not available for reference); LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 111, Pl. 16, fig. 9.

Description: The leaf is about 7 cm. long and 4.5 cm. wide; ovate, acute, constricted below the apex (broken), entire; base imperfect. Five pairs of secondaries are visible, the lowermost thin, unbranched, and close to the border (only a part of this one can be seen). The second and third pairs of secondaries are strong and branched on the outer side; these both extending along the border for about two-thirds of the length of the leaf. They branch from the straight, strong midrib at an angle of about 40°. The upper pairs of secondaries are opposite, considerably curved and thinner than the third and fourth pairs. The nervation is camptodrome, forming a row of arches along the borders. I refer this leaf to *Diospyros Steenstrupi* with some hesitation.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cre-

taceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 53*).

59. **Diospyros primæva** Heer.

Diospyros primæva HEER, Phyllites Crétacées du Nebraska, 1866, p. 19, Pl. 1, figs. 6, 7; Flora Fossilis Arctica, VI, Abth. 2, 1882, p. 80, Pl. 17, fig. 1; *Ibid.*, VII, 1883, p. 31, Pl. 61, figs. 5a., b., c. (None of above available for reference); LESQUEREUX, Illustrations of Cretaceous and Tertiary Plants, 1878, Pl. 3, fig. 8; Cretaceous and Tertiary Flora, U. S. Geological Survey, VIII, 1883, p. 59; The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 109, Pl. 20, figs. 1–3; SMITH, Geology Coastal Plain in Alabama, 1894, p. 348; NEWBERRY, The Flora of the Amboy Clays. U. S. Geological Survey, Monograph XXVI, 1895, p. 124, Pl. 30, figs. 1–5; KNOWLTON, 21st Annual Report U. S. Geological Survey, Pt. 7, 1901, p. 317, Pl. 39, fig. 3; BERRY, Bulletin Torrey Botanical Club, XXXII, 1905, Pl. 2; *Ibid.*, XXXIV, 1907, p. 204; The Flora of the Karitan Formation, Geological Survey of N. J., Bulletin 3, 1911, p. 211.

Description: The base and apex of the leaf are not perfect. The leaf is about 10 cm. long and 5 cm. wide. It has seven or eight pairs of secondaries with a smaller, fainter, secondary near the basal border. In outline and venation the leaf resembles those described and figured by Lesquereux and Newberry, *op. cit.* The specimen is of the Sternberg Collection, from the U. S. National Museum, and bore a label referring it to *Diospyros rotundifolia.* The resemblance to *Diospyros rotundifolia* is much less than to *Diospyros primæva* and I, therefore, have referred it to the latter species.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Chas. H. Sternberg Collection, Accession No. 4799, Carnegie Museum, Pittsburgh, Pa. (*No. 66*).

RUBIALES.

Family CAPRIFOLIACEÆ.

Genus VIBURNUM.

60. **Viburnum Lesquereuxii** Ward.

Viburnum Lesquereuxii WARD, in LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 121.

Description: The leaves are ovate, acute, truncate, or somewhat rounded at the base, minutely denticulate. They are about 5.3 cm.

long and 4.5 cm. wide. The midvein is straight and thick. There are six or seven pairs of secondary veins, which are straight, equidistant, and parallel. The lowermost pairs are branched on the under side, the veins and branches passing to teeth in the dentate margin. The leaves correspond to Ward's description (*l. c.*) of *Viburnum Lesquereuxii,* but do not resemble in shape any of the varieties figured by him.

Note: I found with the one leaf a loose label bearing the name "*Viburnum dakotense intermedium,*" but I can not find any such variety in existence. Probably the unknown person who identified this leaf intended to make a new variety, which might be advisable. There are two specimens of this leaf. The one is almost perfect (petiole wanting) and rather distinctly veined; the other merely shows the shape of the leaf. I think they are impressions of the same leaf, as the two seem to fit together.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 32, 32a*).

61. **Viburnum Lesquereuxii** var. **commune** Lesquereux.

Viburnum Lesquereuxii var. *commune* LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 122, Pl. 53, fig. 2. (See footnote, page 121, by Ward.)

Description: There are two specimens of this leaf. The one is about 5.5 cm. long and 4.5 cm. wide near the middle. The other leaf is about 3.7 cm. long and 3.1 cm. wide. Both leaves are almost perfect, showing very distinctly the veining, dentition, and areolation, The larger leaf is a little more rounded than the more oval smaller one. The variation is not sufficient to place them under different species and I think not even sufficient to make separate varieties.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 26, 26a*).

62. **Viburnum sphenophyllum** Knowlton.

Viburnum sphenophyllum KNOWLTON, in LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 123, Pl. 53, fig. 4.

Viburnum cuneatum LESQUEREUX, See footnote p. 123, LESQUEREUX, *op. cit.* Not *Viburnum cŭneatum* NEWBERRY. See NEWBERRY, The Later Extinct Floras of North America, XXXV, 1898, p. 130, Pl. 57, fig. 2.

Description: The leaf is nearly 7 cm. long and 3.7 cm. broad, ovate, broadly cuneiform at the base, tapering to the pointed apex, rather coarsely dentate. Midvein straight, prominent. Secondaries straight, parallel, opposite or nearly opposite, about eight pairs, ramose, none simple and basilar. The teeth are sharply pointed, distinct, and nearly equal. The above description applies to *Nos. 12* and *12d,* which are impressions of the same leaf. *Nos. 12a* and *12b* are also impressions of the same leaf. These specimens are all very well preserved.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*Nos. 12, 12a, 12b, 12d*).

63. **Viburnum Lesquereuxii** Ward, var. **lanceolatum** Lesquereux.

Viburnum Lesquereuxii WARD var. *lanceolatum* LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 123, Pl. 53, fig. 3.

Description: The leaf is about 7.5 cm. long and 4.5 cm. wide. It is oval, tapering gradually to a slightly lanceolate apex. The base is broadly cuneate. The margin, while somewhat broken, seems to be rather regularly toothed. The midrib is heavy at the base, but tapers rapidly, becoming thin toward the apex. There are seven or eight pairs of secondaries which are opposite, except toward the apex, parallel, branching near the border, and craspedodrome. There are two pairs of thinner secondaries near the basal margin which curve backward a little in passing out from the midrib. The smaller veins are not distinct, except near the margin.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Dr. G. Hambach Collection, U. S. National Museum; C. M., Accession No. 4799 (*No. 68*).

64. **Viburnum robustum** Lesquereux.

Viburnum robustum LESQUEREUX, The Flora of the Dakota Group, U. S. Geological Survey, Monograph XVII, 1892, p. 120, Pl. 20, figs. 4–6.

Description: The leaf is 8 cm. long and 4.4 cm. wide near the middle. It is ovate, acute-acuminate, narrowed rather abruptly to a

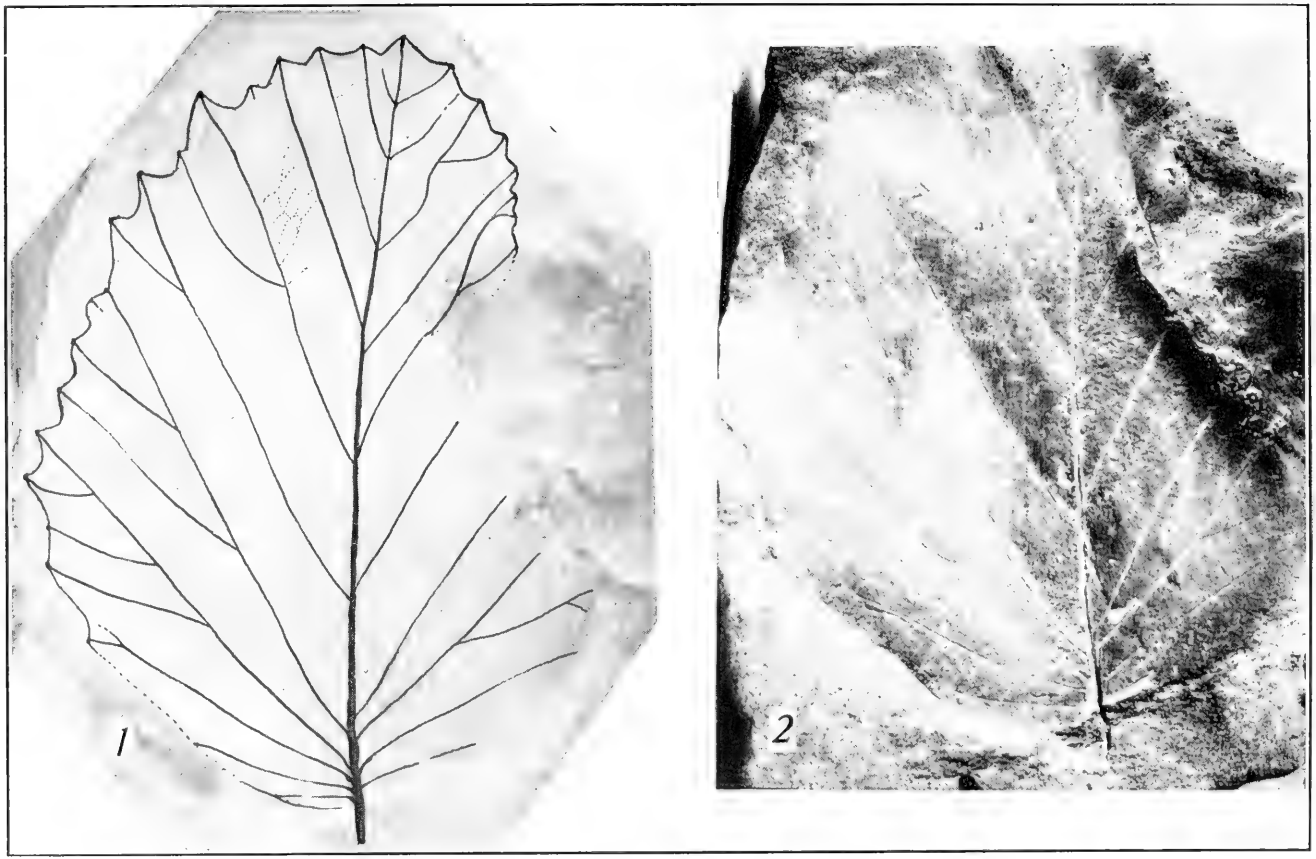
thick petiole. The midvein is very thick toward the base, becoming thin at the apex. There are about seven pairs of secondary veins, the lowermost pairs are opposite, the others alternate. On one side a thin nerve can be seen running near the margin of the base. The secondaries arch in passing to the borders and are camptodrome. Some of them show branching near the middle. The tertiary venation and areolation are not distinct. I refer this specimen to *Viburnum robustum* with a great deal of hesitancy. The leaf in outline and in secondary venation resembles *Diospyros brachysepala* Alex. Braun, as described and figured by Berry in The Lower Eocene Floras of Southeastern North America, U. S. Geological Survey, Professional Paper 91, 1916, p. 333, Pl. 107, fig. 6. Since *Diospyros brachysepala* has not been found in a formation so early as the Dakota, and since the tertiary venation and areolation are not very distinct, I have referred it to *Viburnum robustum*.

Occurrence: Ellsworth County, Kansas, Dakota Sandstone (Cretaceous). Baron de Bayet Collection, Accession No. 2348, Carnegie Museum, Pittsburgh, Pa. (*No. 34*)

EXPLANATION OF PLATE XIV.

FIG. 1. *Protophyllum ovatum* Gress, sp. nov. Leaf, natural size, the outline where intact being inked in.

FIG. 2. Portion of the same specimen, more plainly showing the neuration. (Specimen in the Carnegie Museum, from the Baron de Bayet Collection. Dakota Sandstone, Ellsworth County, Kansas.)



Protophyllum ovatum Gress, sp. nov.

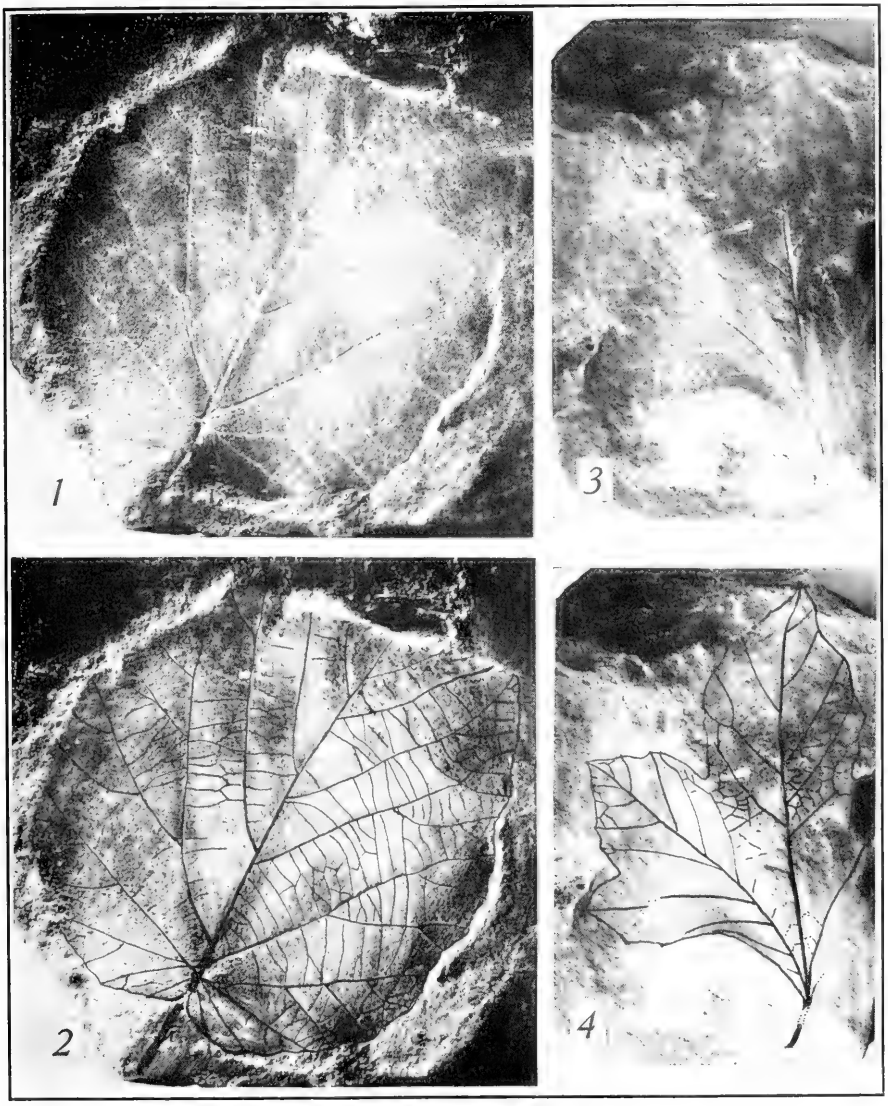
EXPLANATION OF PLATE XV.

FIG. 1. *Protophyllum viburnifolium* Gress, sp. nov. Leaf, slightly reduced below natural size.

FIG. 2. The same specimen with the venation and margin of the leaf inked in, where discernible. Slightly reduced from natural size.

FIG. 3. *Platanus cissitifolia* Gress, sp. nov. Leaf, slightly reduced below natural size.

FIG. 4. The same specimen, with the venation and margin of the leaf inked in where discernible. Slightly reduced from natural size. (The specimens are in the Carnegie Museum.)



1–2. *Protophyllum viburnifolium* Gress, sp. nov.
3–4. *Platanus cissitifolia* Gress, sp. nov.

XI. A COMPARATIVE STUDY OF SOME SUBFOSSIL REMAINS OF BIRDS FROM BERMUDA, INCLUDING THE "CAHOW."

By R. W. Shufeldt.

(Plates XVI–XXXI.)

My interest in the extinct avian fauna of the Bermudas was aroused through receiving the following communication from Dr. F. A. Lucas, Director of the American Museum of Natural History, New York City, dated August 10, 1915: "I had intended writing you a little while ago in regard to a collection of bones of the extinct Cahow of the Bermudas. We have quite a number of these bones that were given us some time ago, and we agreed to pick out a series for the donor. This Mr. Miller has never found time to do, and I wonder if you would be willing to go over the collection for the sake of studying the anatomy of this extinct petrel and pick out a series for us? If this is asking too much, do not hesitate to say so." In reply to this letter, I said, in effect, that I would welcome such an opportunity to study material of that kind; and, further, I would do all he requested in his communication and be glad to work up the entire collection for publication. A brief correspondence promptly followed, terminating in bringing the collection referred to before me at my home, 3356 Eighteenth Street, Washington, D. C.

On the twenty-third of August, 1915, Doctor Lucas wrote me: "I think that Richmond a few years ago wrote a brief paper on the Cahow, and, as you know, Verrill had quite an article on the subject.

"These particular bones came from a very inaccessible cave in the Bermudas, one that there is good reason to suppose had not been explored before the visit of Mr. McGall.[1] He had great difficulty in getting into the part of the cave where these bones were found, as he had to make a descent by ropes."

These letters are interesting, for, in addition to setting forth Doctor Lucas's view that the bones were from species of birds he believed

[1] Mr Edward McGall, 17 Commerce Street, Orange, New Jersey.

to be extinct, as stated in his first letter, it briefly described the locality where the material was found and who collected it. This resulted in my writing to Mr. McGall, the collector, who shortly afterwards, with great generosity, sent me his own private collection of bones taken in the same caves mentioned above. On the seventh of September, 1915, in a letter I received from Mr. McGall, he said: "A few days ago I sent by express some more bones of this same bird, which were obtained from the cave this year. I was fortunate enough to find vertebræ and other of the smaller bones, so that with this addition you will probably have sufficient to make a presentable assembly. Along with the bones were inclosed a small package of decomposed coral stone and a stalactite. The cave is formed entirely of this decomposed coral sand with stalactite roof. You will note that the stalactite is dead and that the bones have kept in such fine shape because of the dryness of this cave. It is also interesting to note that in all of the other caves visited, some eight in all, no bones of any sort were found. Most of these caves were still damp and stalactite and stalagmite were growing."

"As regards the horizon, I should say that it is entirely recent, approximately three hundred years."[2]

Being desirous of bringing together all the material possible to work up these most interesting bones, I soon ascertained that, about two years previous to my receiving the two lots referred to in the letters of Doctor Lucas and Mr. McGall, the U. S. National Museum had in its collections some more material, which very likely was of the same character. Upon due investigation it became evident that this material had, for some purpose or other, been sent to the American Museum of Natural History for examination, and probably was in the possession of Doctor Lucas. After a little interesting corre-

[2] In addition to the bird bones which made up Mr. McGall's collection, I found the claw of some medium-sized crustacean; and, believing that it might prove of interest to identify the species, I submitted the specimen to Miss Mary J. Rathbun, the well-known carcinologist of the U. S. National Museum, who kindly pronounced it to be "a sub-fossil movable finger of *Gecarcinus lagostoma* M. Edw." Miss Rathbun further stated that while "The species is recent, it was not known to live in Bermuda." In other words, this was a part of a claw of a crab, the distribution of which at one time included the Bermudas, but which now is extinct there and probably over still more of its former range.

spondence, he kindly placed that material before me likewise.[3] It was received and receipted for by me on the first of November, 1915, and it will be listed beyond. Two days thereafter I received the following communication from Doctor Lucas: "I am very glad to be able to report to you that the bones of the Cahow (*Æstrelata*), from Bermuda, which were forwarded us in December, 1913, by the United States National Museum for purposes of comparison, have been found, and they were sent to you a few days ago. I trust they will reach you safely.

"I am enclosing herewith, for your information, the correspondence relating to the transmittal of the specimens, together with the remarks of Doctor Richmond and Doctor Stejneger on the bones of this interesting bird. It is really very good of you to go into this matter so thoroughly."

The correspondence referred to consists of the usual letter of transmittal, signed by the Assistant Secretary in Charge of the National Museum, and (2) the "Invoice of Specimens" for "Examination," dated November 29, 1913, consisting of "Æstrelata" "Cahow," from "Bermuda," collected by "L. L. Mowbray" (No. 223888, "numerous bones").

I have the kind permission of Doctor Stejneger and Doctor Richmond to publish the interesting letters they transmitted at the time. The earliest communication is from Dr. C. W. Richmond, Assistant Curator of Birds, U. S. National Museum, and is addressed to Dr. F. W. True, being dated November 29, 1907. It reads as follows: "I beg to offer the following remarks on the bones of the 'Cahow' presented to the Museum by Mr. Mowbray:

"The material consists of a fragmentary skull, portions of two upper mandibles, fragments of pelvis and sacrum, and of the sternum and pectoral arch, and the following single bones: humerus (6), tibia (3), fibula (1), radius (2), ulna (1), femur (2), metatarsus (1), metacarpus (2), coracoids (2), digits (3), besides several fragments of smaller bones (ribs, etc.).

"Although we have no bones of the West Indian species for com-

[3] In his letter of October 29, 1915, he says: "I have been overwhelmed with work since returning from my vacation, but will drop a line to say that the *Puffinus* material you have naturally been clamoring for turned up yesterday. I sent out a S.O.S. call and it was found. Shall be sent to you promptly."

parison, the skull and mandibles prove the Bermuda bird to have been one of the genus *Æstrelata.* I have carefully compared certain bones (metatarsus, radius and ulna, and mandibles) with skins of *Æ. caribbæa* and *Æ. hasitata,* the only species known to occur in or near the West Indies, and find them to agree very closely in length with the corresponding bones of *Æ. caribbæa* (as nearly as I can make them out through the skin and feathers). A comparison with the skin of *Æ. hasitata* proves that they are too short for that species. The bones found by Mr. Mowbray, therefore, belong to a species probably identical in size with *Æ. caribbæa,* but the color of the 'Cahow,' as described by the early colonists of Bermuda, differs from the Jamaica Petrel (*Æ. caribbæa*) in having the wings russet and white, with a russet back and white belly. The Jamaican bird is sooty brown with blackish head, wings, and back, and whitish or ashy upper tail-coverts. Russet is a color unknown in this genus, and, so far as known, in the family. Mr. Mowbray told me, however, that he had found one or two russet feathers among the remains taken from the cave in Bailey's Bay, which apparently confirms the statements of the early colonists, and would indicate the "Cahow" to be a distinct species of *Æstrelata,* now extinct, and not yet provided with a name.

"The habits of the 'Cahow' are well described by Butler, Strachy, Hughes, and others, as given by Verrill (*Trans. Conn. Acad. Sci.,* XI, 1902, 668–677), but unfortunately I have been able to find nothing of importance on the habits of either *Æ. caribbæa* or *Æ. hasitata.*

"Very respectfully,

[Signed] CHAS. W. RICHMOND."

On December 1, 1907, Doctor Stejneger sent the following "Memorandum" to Dr. F. W. True:

"Dr. Richmond's note is interesting enough to deserve publication. I do not believe, however, that his conclusion as to the specific distinction of the 'Cahow' based on the *russet* color is well founded. As he says correctly: 'Russet is a color unknown in this genus,' etc., but he evidently only thinks of *russet* as represented by Ridgway's 'Nomenclature of Color,' pl. iii, fig. 16, but the early colonists of Bermuda certainly did not make such a fine discrimination in the application of the term. As the Century Dictionary says, *Russet* is 'a broad and vague term, formerly applied to various shades of gray

and brown or ash-color, sometimes used restrictively, but in no well-settled sense.' The color of *Æstrelata caribbæa* might well have been described by them as *russet*.

L. S."

This communication was followed by another "Memorandum" from Doctor Stejneger, addressed to Dr. F. W. True, and dated January 2, 1908; it read as follows:

"As requested by you, I have gone over Mr. Mowbray's material with Dr. Richmond, and came essentially to the same result as he, viz., that the bones belong to an undescribed species of *Æstrelata* having the size of *Æ. caribbæa* and the coloration of the somewhat larger *Æ. hasitata*. This of course under the supposition that the bones belong to the 'Cahow' as described by the early colonists. As for the 'russet' color, I am of the belief that the colonists by this designation meant the brownish-grayish color so characteristic of these birds. As Mr. Mowbray is said to have some feathers of a 'russet' color, he may be able to throw some light on this question.

"Dr. Richmond thinks that probably Mr. Mowbray himself might want to publish the matter, as he has only asked the Museum to identify the material.

"Respectfully,

[Signed] LEONARD STEJNEGER."

Doctor Richmond, in his letter of November 29, 1913, set forth above, gives a list of the material representing these subfossil birds of Bermuda belonging to the U. S. National Museum. I find this list substantially correct, so it is unnecessary to duplicate it here; it will be described further on in the present paper.

A short time after the bones from the American Museum of Natural History, and those forming the collection of Mr. McGall, were in my possession, I separated, in the case of both, the various bones into groups, placing all the skulls together, all the vertebræ, all the different long bones, ribs, digits, and so on. After this had been accomplished with the greatest care, I prepared two lists of the material as follows:

LIST OF MATERIAL FROM THE AMERICAN MUSEUM OF NATURAL HISTORY.

3 crania (more or less incomplete).
3 quadrate bones.
3 mandibles and five fragments of others.
49 vertebræ (chiefly cervical and dorsal, including three axes, only one caudal vertebra, and no atlas).
49 vertebral ribs (all nearly perfect).
16 costal ribs (all nearly perfect).
6 sterna (one fragment, five nearly perfect).
8 sacra (more or less perfect, with ossa innominata for nearly all of them).
8 coracoids (five lefts and three rights).
9 scapulæ (three lefts and six rights; all very nearly perfect save one, the distal end of which is lost).
4 ossa furculæ (fragments of two others).
20 humeri (eleven of right limb and nine of the left; all very nearly perfect save two; one right humerus has but the proximal half or rather more).
5 ulnæ (three rights, two lefts).
17 radii (eight of one side, nine of the other; all nearly perfect).
15 metacarpi (nine rights and six lefts; all nearly perfect).
6 phalangeal joints (proximal ones of index digits; all very nearly perfect; one of right limb and five of the left).
4 distal phalanges (three of pollex and one of index digits).
9 femora (five of left pelvic limb and four of the right).
12 tibio-tarsi (four of right limbs and eight of the left; more or less perfect).
1 fibula (right side).
16 tarso-metatarsi (eight from either side; all nearly perfect).
5 pedal phalanges.

BONES REPRESENTING A SMALLER SPECIES.

(To be described further on in this paper. Apparently all belonged to the same individual, with the exception of the two tibio-tarsi.)

1 cranium (more or less imperfect).
4 fragments of a sternum.

2 ossa innominata (quite perfect).
2 bones of the forearm (left side).
1 carpo-metacarpus (left side).
2 tibio-tarsi (different individuals; quite perfect).
1 tarso-metatarsi (right limb; perfect).

LIST OF MATERIAL IN THE COLLECTION OF MR. EDWARD MCGALL.

5 crania (more or less incomplete).
5 quadrate bones.
3 mandibles and four fragments of others.
1 mandible of another species.
64 vertebræ (chiefly cervical and dorsal, including one atlas and one axis; four caudals, and six of a smaller species).
69 vertebral ribs (including a few imperfect ones).
34 costal ribs (including a few imperfect ones).
1 *very small* vertebral rib
1 *very small* costal rib } different species.
5 sterna.
1 sternum of a larger species.
7 ossa innominata (no sacrums).
3 coracoids.
1 coracoid of another species (smaller).
8 scapulæ (two rights, six lefts).
6 ossa furculæ and three fragments of others.
1 broken one of a smaller species.
30 humeri (ten rights, twenty lefts; all perfect).
5 humeri, smaller species (two rights, three lefts).
35 ulnæ (twenty rights, fifteen lefts).
3 ulnæ, smaller species (one right, two lefts).
33 radii (perfect).
1 radius of a smaller species.
13 carpo-metacarpi (six rights, seven lefts).
1 carpo-metacarpus of a smaller species (right).

PHALANGEAL JOINTS.

6 proximal of index.
1 proximal of index, smaller species.

11 terminals.
7 femora (three rights, four lefts).
10 tibio-tarsi (five rights, five lefts).
2 tibio-tarsi of another species (one right, one left).
8 fibulæ.
10 tarso-metatarsi (six rights, four lefts).
1 tarso-metatarsus of another species.
42 pedal phalanges (not assorted).

This preliminary going over of the material gave me quite an insight as to its nature, value, and not a few of the characters of the various bones; when, shortly after it had been arranged for study, I received as a loan, through the kindness of Doctor Richmond, the following skeletons and parts of skeletons from the collections of the U. S. National Museum:

LIST OF MATERIAL FOR COMPARISON.

(Existing species.)

1. *Daption capense.* No. 18210. Skull and other bones.
2. *Oceanodroma leucorhoa.* Nos. 18077, 18078. Skeletons.
3. *Æstrelata lessoni.* No. 14494. Skull.
4. *Cookalaria cookii.* No. 18285. Skeleton.
5. *Pelecanoides urinatrix.* No. 18771. Skeleton.
6. *Puffinus major.* No. 18076. Skeleton.
7. *Puffinus gavia.* No. 18286. Skeleton.
8. *Puffinus gavia.* No. 19385. Skeleton, trunk.
9. *Puffinus borealis.* No. 17769. Skeleton.
10. *Puffinus griseus.* No. 19386. Skeleton, trunk.
11. *Fulmarus glacialis.* No. 15731.
12. *Fulmarus glacialis.* No. 15732. } Imperfect skeletons.
13. *Fulmarus glacialis.* No. 15728.
14. *Fulmarus glacialis.* No. 16781. Skeleton.
15. *Puffinus obscurus.* No. 17724. Imperfect skeleton.
16. *Puffinus creatopus.* No. 18773. Skeleton.
17. *Puffinus borealis.* No. 17767. Skeleton.
18. *Puffinus major.* 17799. Skeleton.

To these were added several skeletons of *Colymbus auritus, C. cristatus,* and *Podilymbus podiceps.*

This represented all the material in the collections of the U. S. National Museum which could be of any use whatever in the way of comparison; it is very evident that, in so far as skeletons of *Æstrelata* of any species are concerned, it is a long way from being of either the proper kind or in sufficient quantity. This being the case, I at once put myself in communication with other naturalists and institutions with the hope of augmenting it. I was surprised to find how very little material of the kind was to be found in the collections of either private individuals or of institutions. For example, Dr. Frank E. Beddard, F.R.S., Prosector of the Zoölogical Society of London, wrote me on the 12th of October, 1915, to the effect that "I fear that I am of no use to you in the matter of which you write. The collection here of birds' skeletons does not include the types you require. I am sorry not to be able to help you." Dr. Arthur Keith, F.R.C.S., Conservator of the Museum of the Royal College of Surgeons of England, in his note of the 11th of October, 1915, said: "I would send you the tracings and drawings with good-will, but unfortunately Mr. Bedone and his assistant—who have charge of the Bird part of the Museum—are in France, and I do not know when they may return. Indeed—at present—the Museum is shut down and only the more urgent work is being carried on. But as soon as my men come back you shall have the facts you are in need of.

"With kindest regards,

"Yours sincerely,

[Signed] A. KEITH."

This kind note spoke only too plainly of the effect of the great European war upon the scientific institutions in London.

As Prof. C. J. Maynard had collected extensively in the Bermudas, I wrote to him with the view of ascertaining whether he had in his collections any skeletons of Petrels and Shearwaters that might be of value by way of comparison in the work in hand. On the 6th of September, 1915, he wrote me from his home at West Newton, Massachusetts to the effect that "I am sorry to have to tell you that I have no complete skeleton of Audubon's Shearwater, but have a sternum which I shall be glad to lend to you if that will be of service to you. It is roughed out, as sternums are best kept in this condition until wanted.

"Very truly yours,

[Signed] C. J. MAYNARD."

This was followed by a postal card, dated September 10, 1915, upon which he said: "I am sending you the Audubon Shearwater sternum by this mail. Yes, it is a perfect sternum, shoulder-girdle and all. This was, and still is, my method of collecting sternums of Aves, of which I have a large number of many species. Shall be glad to see your paper." Finally, Professor Maynard sent me the following letter, under date of September 17, 1915:

"When I collected the Shearwater from which the sternum was taken that I sent to you the species was known as *Puffinus obscurus* Gm. (see Coues Key, 1894, p. 786). I presume that it was then considered the same as the Indian Ocean species. It was, however, separated by Finsch in 1872 and named *P. Auduboni* (P. Z. S., 1872, 111).

"Now it seems, as you say, we must call it *Puffinus lherminieri.*

"You will find an account of the soft parts of a portion of the internal structure in my Birds of Eastern North America, Revised Edition 1897, p. 35. This book is, I think, in the Smithsonian or National Museum library.

"Did I tell you in my last that I shall be glad to have you clean that sternum? I intended to have done so, if I did not.

"I shall be pleased to read your opinion regarding the identity of the "Cahow" of Bermuda in your forthcoming paper.

"If I do go to the Bahamas this coming spring I will try and get a skeleton or two of Audubon's Shearwater.

"Very truly yours,

[Signed] C. J. MAYNARD."

Desiring to measure the wing and leg bones in the case of certain petrels as best I could, and having been informed by Doctor Richmond that Prof. Leverett M. Loomis, of the California Academy of Sciences, had had in his possession for study for a very long time the unique skins of *Æstrelata caribbæa* and *Æ. hasitata,* I wrote him, requesting him to obtain the aforesaid desired lengths of the ulnæ and tarso-metatarsi for me. The skins in question belonged to the U. S. National Museum, and are of particular value, as it is very probable that both species are now to be numbered among the extinct birds of America. In reply I received the following communication:

"SAN FRANCISCO, Oct. 16, 1915.

"*Dear Doctor Shufeldt:* "In order that the personal equation may be maintained in your measurements, I will return next week to the National Museum the specimens of *Æstrelata caribbæa,* also the specimen of *Æstrelata hasitata.*

"I think there are several specimens of these birds in the Cory collection at the Field Museum.

"Sincerely yours,

[Signed] LEVERETT MILLS LOOMIS."

A letter from me on the subject to Mr. Cory, addressed to the Field Museum of Natural History, Chicago, brought a reply (Nov. 12, 1915) to the effect that "We have no skeletons or skulls which you ask for, so can not help you out in this matter.

"Very sincerely yours,

[Signed] CHARLES B. CORY,

Curator of Zoölogy."

Believing there might be something I could use in the collection of the Museum of Comparative Zoölogy, at Cambridge, I wrote to Prof. Hubert Lyman Clark in regard to the matter, and the following communication was received from that institution:

"October 4, 1915.

"DR. R. W. SHUFELDT,

"Washington, D. C.

"*Dear Sir:* Answering your letter addressed to Dr. Clark, I regret that our series of specimens does not include any of the species of *Puffinus* or *Œstrelata* that you ask for, though we may have some of these forms in alcohol, and at a later date these alcoholic specimens may be accessible.

"We have a complete skeleton of *Œstrelata lessoni.* If this will be of service in your work, I shall be glad to loan it to you for a short time.

"Yours truly,

[Signed] SAMUEL HENSHAW,

Director."

Replying that I would be very glad to see the skeleton referred to, the following came to hand (Oct. 18, 1915): "I am sending by ex-

press, charges collect, the skeleton of *Œstrelata lessoni,* and I hope it will reach you in good condition and answer your purpose.

"I have delayed the sending that we might examine our alcoholic material. This has now been done, and I regret that we have no specimens of *Puffinus* or *Œstrelata.*

"Yours truly,

[Signed] SAMUEL HENSHAW,
Director."

I was surprised to find that the specimen was a most carefully *mounted one,*[4] and I felt all the more grateful for the unusual courtesy extended. At once I compared it with the descriptions of Forbes of *Æstrelata lessoni,* and found that it must have belonged to a much smaller and entirely different species.[5] This being the case, I wrote Professor Henshaw for particulars, receiving the following reply:

"October 28, 1915.

"DR. R. W. SHUFELDT,
"Washington, D. C.

"*Dear Sir:* Answering your letter in regard to the skeleton of *Œstrelata lessoni,* I regret that the data may not prove wholly satisfactory.

"It was bought by Mr. Agassiz in January, 1884, of Prof. H. A. Ward. The only locality recorded is New Zealand.

"The entry in the catalogue is in the hand of Dr. J. A. Allen.

"Yours truly,

[Signed] SAMUEL HENSHAW,
Director."

Matters having proceeded thus far, I invited Mr. Austin H. Clark, of the U. S. National Museum, to examine the material with me, an

[4] I have since made a good negative of this bird, and it will be described further on in this paper.

[5] Forbes, William Alexander. "Report on the Anatomy of the Petrels (*Tubinares*) Collected during the Voyage of H. M. S. *Challenger,*" Vol. IV, Pt. XI, p. 1. (Plates XII–XXIV.) See also "The Scientific Papers of W. A. Forbes," pp. 363–440 (plates with same numbers). The skull of "*Œstrelata lessoni*" (3 views) are presented on Plate XXII. It is very considerably larger than the skull of the specimen I received from the Museum of Comparative Zoölogy, which is numbered 1429.

invitation he kindly accepted. In a few days thereafter he submitted me the following communication on the subject, which is valuable, to the point, and here published *in extenso:*

"SMITHSONIAN INSTITUTION.
"UNITED STATES NATIONAL MUSEUM.
"WASHINGTON, D. C.

"November 2, 1915.

"DR. R. W. SHUFELDT,
"3356 Eighteenth St.,
"Washington, D. C.

"*Dear Dr. Shufeldt:* Before reaching a conclusion based directly upon the examination of the bird skeletons from Bermuda which you recently showed me, it is well to review the information at hand regarding the comparable elements in the avifauna of the West India islands further to the south, islands in their marine fauna (upon which the sea-birds are dependent for their existence) not essentially different from Bermuda.

"Aside from the shore-birds and gulls, gannets, tropic-birds, etc., which may at once be excluded from consideration, we find that Guadeloupe originally supported at least two, and possibly three, species of shearwaters, (1) *Puffinus lherminieri* (= *Puffinus audubonî* auct.) and (2) *Æstrelata caribbæa* (= *Æstrelata jamaicensis* auct.); certain evidence seems to point to the occurrence of another, white breasted, species of *Æstrelata,* which may have been *Æstrelata hasitata.* The famous 'Diablotin,' so called from its nocturnal habits and weird cry, and once a very important article of food, was *Æstrelata caribbæa,* or a very closely related form.

"On Jamaica there was the same complex, (1) *Puffinus lherminieri* and (2) *Æstrelata caribbæa.*

"The 'Pimlico' of Bermuda (still so called) was *Puffinus lherminieri* (given by Hurdis and Reid as *P. obscurus*), or the first element in the complex of Guadeloupe and Jamaica; and I can see no reason to suppose that your small skeletons are anything else.

"From the very close similarity of the habits of the Cahow and those of the Diablotin as recorded by the naturalists of Guadeloupe it seems almost certain that the former could have been nothing else

than a species of the genus *Æstrelata,* representing the second element in the complex found on Guadeloupe and Jamaica. The larger skeletons seem undoubtedly to be those of a representative of that genus, though which species can not be determined without more abundant material for comparison.

"Verrill does not believe that the Cahow could have been a petrel, but his objections do not seem to me to be very weighty.

"The Cahow usually bred in holes, and not in natural caves and crevices like the Diablotin; this difference in habit is not significant; the Bermuda Bluebird is peculiar in building nests and not laying in holes like other bluebirds; yet I once found a nest in one of the holes in the capstan of a wrecked ship near the Flatts. The Tropic Birds at Bermuda nest in holes, or at least in deep crevices, which is not by any means a universal habit of the allied species farther south. *Puffinus lherminieri* breeds either in crevices or in holes of greater or less depth according to circumstances.

"I see no reason for doubting, as Verrill does, the statement of Governor Butler that the eggs and young of the Cahow were found in crevices of the ledges, though of course I would assume that this was in addition to the usual occurrence in holes.

"The flesh and eggs of the Diablotin at Guadeloupe were just as highly esteemed as food as those of the Cahow at Bermuda; the Diablotin was undoubtedly a shearwater; therefore I can not see the force of Verrill's remarks regarding the West Indian shearwaters that 'their eggs are so musky that they are not edible; certainly no one would compare them to a hen's egg. Their flesh also has so strong a flavor of bad fish-oil and musk that no one would eat it, unless on the verge of starvation, though the newly hatched young are sometimes eaten by sailors for lack of anything better.' Barring the fact that styles and tastes in food change just as much as styles and tastes in anything else, and also that the Englishman of the seventeenth century was very far from being so discriminating as the Englishman of the present day, the young of *Puffinus lherminieri* are still sold readily in the West Indian markets wherever they are procurable.

"The color of the Cahow is recorded as 'inclining to russet, with white bellies, as are likewise the long feathers of their wings, russet and white [1610].' The 'russet' of the present day is a color entirely

unknown among the petrels; but in the sixteenth and seventeenth centuries 'russet' was applied to various shades of gray and brown or ash-color, sometimes used restrictively, though in no well-settled sense. Thus in Florio's 'Worlde of Wordes,' 1598, we find the following: 'Grigietto [grigio (Italian) + diminutive ending], a fine graie or sheepes russet.'

"From the literature there is not the slightest reason to suppose that the Cahow of Bermuda was not a species, though possibly a local and distinctive form, of the genus *Æstrelata*.

"Sincerely yours,

[Signed] AUSTIN H. CLARK."

As Prof. A. E. Verrill was so thoroughly identified with the working out of the zoölogy of the Bermudas, both in the matter of the existing fauna of the islands and with its presumably extinct forms, I made an attempt to get into touch with him in the work I now had fairly under way. My letter eventually reached him, calling forth the following reply:

"NORWAY, MAINE, Oct. 24, 1915.

"*Dear Sir:* Your favor of August 25th relating to Bermuda bird bones interested me very much. I suppose they are the same found by Mr. Mowbray several years ago. I tried at that time to have them sent to some expert osteologist, but could not. Perhaps later ones have been found in the newly discovered caves there. . . . As soon as I return, probably this week, I will see if we have skeletons of the species you wish, if some one else has not already done so. Dr. Geo. Eaton, who is Curator of Osteology, was away of course during college vacation. Whether he is now back I don't know, but presume he is.

"Very respectfully yours,

[Signed] A. E. VERRILL.

"P. S.—We have no fossil bones from Bermuda that would be of use to you. If you lack any of my papers on that subject (Cahow) I can send you copies."

Later on I received the following letter from Mr. W. P. Pycraft, of the British Museum:

"BRITISH MUSEUM (NATURAL HISTORY),
"CROMWELL ROAD, LONDON, S. W.,
"8. XI. 15.

"*Dear Sir:* Your request for skeletons has been passed on to me, as I have charge of the Osteological collections from birds, up to and including Man.

"I have no skeletons that I could send out on loan, even if there were no risks attendant on their passage out and home.

"Neither is it possible to send drawings.

"Most of my staff are absent in the trenches, and thus it is hard to cope with the ordinary curatorial work of the Department.

"Yours truly,
[Signed] W. P. PYCRAFT."

At this stage of my inquiry I devoted myself to examining some of the previous literature upon the "Cahow," though it did not seem necessary to enter very exhaustively upon this. It was known to me that Doctor Richmond had gone extensively into this part of the subject; and after having done so, as shown in one of his letters on a previous page of this article, he came to a definite opinion in the premises, that the "Cahow" was an *Æstrelata*. Had I read all the literature gone over by Doctor Richmond, I should, no doubt, have come to precisely the same opinion; others have already done so before me, so there is nothing in particular to be gained by reopening the literary side of the subject.

The early writers did little or nothing with the osteology of the Petrels and Shearwaters of Bermuda; the question of the color (russet) has been thoroughly gone over; the skins of these birds in existence are very few, indeed, in any museum (*Æstrelata caribbæa* and *Æ. hasitata*), and the early ornithologists have left us no exact measurements of them, nor data upon their distribution. However, I have gone over some of the "Cahow" literature with great care; but, though this is interesting and to some degree helpful, the conclusions reached in the present contribution will be based almost entirely upon the actual material at hand.[6]

[6] I have read the following accounts on the "Cahow":

Verrill, Addison E., "The Bermuda Islands," Vol. I, Supplement to the Second Edition. Publ. by the author, New Haven, Conn., 1907, p. 572. *The American Naturalist*, Vol. 38, No. 451, p. 555, 1904.

In summing up the "*known characteristics of the Cahow,*" Professor Verrill came to the conclusion that in their combination the species differed from all known birds. (*Pop. Sci. Monthly,* Vol. IX, p. 22, Nov., 1901; also *Ann. and Mag. Nat. Hist.,* Vol. IX, p. 26, Jan., 1902.)

As the skins which were in the possession of Prof. Leverett M. Loomis were at hand (see his letter *antéa*), and also the "Cahow" material belonging to the U. S. National Museum which Doctor Lucas had, there were some comparable characters which could be disposed of at this stage of the examination.

In the latter lot there is to be found the curved, distal extremity of the superior mandible of an adult "Cahow," which is still covered with its horny sheath or mandibular theca; it is the only beak so covered in all the material representing the subfossil bird bones from Bermuda before me. This is important from the fact that it gives the exact *form* of the end of the superior mandible *as in life.*

On November 3, 1915, at the U. S. National Museum, I compared this sheathed piece of an upper mandible of a "Cahow" with the corresponding part in *Æstrelata caribbæa* and in *Puffinus lherminieri* (Audubon's Shearwater). The examination convinced me of the fact that this subfossil, horn-covered piece of the upper bill came from a species of Petrel (*Æstrelata*) rather than from that of a Shearwater (*Puffinus*), as the interval between the independently curved, terminal

Tristram, Rev. Henry B., *Annals and Magazine of Natural History,* IX, No. 49, Jan., 1902.

Jones, J. Matthew, and Goode, George Brown, "Contributions to the Natural History of the Bermudas," Vol. I, Washington, Government Printing Office, 1884, pp. 274, 276. This is an early and very interesting account; it is Part IV of the aforesaid "Contributions," and entitled "The Birds of Bermuda." by Captain G. Saville Reid, F. Z. S., etc. Captain Reid believed the "Cahow" and *Puffinus obscurus* (*Puffinus lherminieri*) to be identical.

Verrill, Addison E., "The Bermuda Islands." An account of their scenery, climate, productions, physiography, natural history and geology, with sketches of their discovery and early history, and the changes in their flora and fauna due to man. With 38 Plates and over 250 cuts in the text. Reprinted from the *Trans. Conn. Acad. of Science,* Vol. XI, with some changes. Publ. by the author, New Haven, Conn., 1902, pp. 249, 256–267, 449. On pages 313, 448 and 449 of this volume, Professor Verrill gives numerous other works treating of the birds of Bermuda in general, and of the "Cahow" in particular—as those of William Jardine, John L. Hurdis, J. M. Jones, G. Saville Reid, D. Webster Prentiss, Lieut. H. Denison, Witmer Stone, and others.

piece and the anterior narial apertures was altogether too short for a Shearwater, while it quite agreed with those parts in *Æstrelata*. The piece, however, is not sufficient to decide, with certainty, as to what *species* of *Æstrelata* it may have belonged in life. It *almost* agreed in size and form with the beak in *Æstrelata caribbæa*, though quite possibly it may have agreed with the same part in some other petrel of that genus *of a different species*. Upon comparing it with other terminal parts of the superior mandible in other specimens of the skulls in the Bermuda collections at hand, I found that it very evidently belonged to a species abundantly represented therein, as will be shown further on in this paper.

A short time before this examination, or upon the 29th of October, 1915, I had made another, which also brought to light some important and interesting results, as compared with those made by Doctor Richmond; I refer to the *skins* of *Æstrelata caribbæa* and *Æ. hasitata*, both species being now probably extinct. Of these skins I examined two of the first named and one of the latter. Each specimen of *Æstrelata caribbæa* had two labels—the original and its duplicate. One of the specimens is a male and the other a female. They are sooty-brown birds with ashy rumps, and were collected on the same day and in the same locality. The original label on the female bird reads: "Edward Newton (2) *Æstrelata caribbæa* ♀, 17. 11. 79. Hab. Cinchona Pls. St. Andw. W. Rock, Jamaica," and on the other side "80859." The National Museum label reads: "80859 *Æstrelata caribbæa* ♀, Cinchona Plantations, S. Andrews, W. Rock, Jamaica," and the reverse side: "Edward Newton, Nov. 17, 1879." The labels on the *male* bird are the same, with the exception that the National Museum number is 80860.

Measuring the bones as best I could through the skin in all cases, and disregarding the theca of the superior mandible, I obtained the following results: In the male bird, the *left ulna* has a total length of 9.50 or 9.51 cms.; the left tarsus 3.52 cms.; the length of the skull is 7.00 cms.

In the female bird, the *right ulna* has a length of 9.51 cms.; the right tarsus 3.51 cms.; and the length of the skull seems to be somewhat longer than in the male, having a length of 7.25 cms.

The fact that the skull of the female is slightly longer than that of the male is doubtless due to the fact that, in skinning the bird, the

skull of the former was not cut away as extensively as it was in the male, and therefore was not left as short. For all practical purposes, the ulna measures in length a little over nine and a half centimeters, and the tarso-metatarsus rather more than three and a half centimeters in either the male or the female bird of *Æstrelata caribbæa*.

The specimen I examined of *Æstrelata hasitata* also had two labels, both being alike. On the obverse side we find: "*Æstrelata hasitata* ad., No. 152522. Near Winchester, Virginia, Dr. W. F. Hutchinson"; on the reverse side: "Last of August, 1893. One of a pair (♂ and ♀) picked up near Winchester, Va., after an eastern storm. They were in an exhausted condition."

In this specimen the proximal third of the left ulna is not present. There are glass eyes in the orbits. The right ulna has a length of 11.15 cms.; the right carpo-metacarpus 4.25 cms. (approx.); and the right tarso-metatarsus 4.0 cms.

The lengths of these various bones will be taken up again further on in the present article, when I come to compare them with the corresponding bones in the several lots of the Bermuda specimens at hand.

It will be advisable, in the first place, to critically examine the recent material I have before me for comparison with the Bermuda specimens, in that it may, at the outstart, be decided which part of it will be of assistance and which will not.

I shall take up first the *sternums, shoulder-girdle,* and *costal ribs* or hæmapophyses of the specimen of *Puffinus obscurus,* loaned me by Mr. C. J. Maynard, and referred to by him in his letter of September 17, 1915 (see *antéa*). There should be no question about the identification here, and Mr. Maynard has the skin of the bird in his private collection. He admits in his letter that it is an Audubon's Shearwater—that is, *Puffinus lherminieri.* This *sternum* and *pectoral arch* are shown on Plate XXII, fig. 33, and on Plate XXIII, fig. 34, and it is, except in one instance, very unlike any sternum or pectoral arch to be found in the Bermuda specimens. *None* of the latter, therefore, represent Audubon's Shearwater (*Puffinus lherminieri*). With respect to the excepted specimen, this latter is here figured on Plate XXII, fig. 29, and on Plate XXIII, fig. 36. This subfossil specimen from Bermuda, which I find in the collection of Mr. McGall, is the sternum of a *Puffinus* larger than *P. lherminieri,* and I shall describe it further on in the present contribution.

Passing to the skeleton marked "*Puffinus obscurus*" (No. 17724 of the collection of the U. S. National Museum), here shown on Plate XXII, fig. 28, and Plate XXIII, fig. 35, it is at once evident that it belonged to a very different bird from Mr. Maynard's *Puffinus obscurus*. It is the only skeleton of the kind in the collection of the U. S. National Museum; and, as the species is not represented among the subfossil bones from Bermuda, it may therefore be set aside to be used further on in the present connection. Before doing so, however, I will say that the skull of this specimen, although evidently not of the same species, agrees in many particulars and characters with the skull of the "*Æstrelata lessoni*" from the Museum of Comparative Zoölogy of Harvard University. (See Pl. XVI, fig. 6; Pl. XVIII, fig. 16; and Pl. XXXI, fig. 126.) Coues, in the Fifth Edition of his "Key," gives the length of the "tarsus" as 1.60 in *Puffinus audubonì* (= *P. lherminieri*); and I find that the metatarsus of this "*P. obscurus*" skeleton (No. 17724, Coll. U. S. Nat. Mus.) measures in length but 1.50 (inches). Still, it is a very much smaller bird, with entirely different sternum from the *Puffinus obscurus* in the Maynard collection; fortunately neither agree with any of the Bermuda specimens.

Among these Petrels and Shearwaters we find sterna of *two kinds*, namely, one in which the *body* is nearly square in outline, when viewed directly from above or from below. Such sterna may be either large or small. (Compare figures on Plates XIX–XXIII.)

There is a skeleton of "*Puffinus gavia*" in the collection of the U. S. National Museum (No. 18286) which is from a bird of about the same size as No. 17724 ("*P. obscurus*") and with many of its characters in agreement; but it is not the same species, as is at once evident upon a casual comparison.

A typical Shearwater is seen—in so far as its skeleton is concerned—in the mounted one of *Puffinus borealis* of the U. S. National Museum collection (No. 17772).[7]

Taking into consideration what we have up to this point, it is perfectly safe to say, after comparing the specimens with all the subfossil bones in the three lots of the Bermuda material, that Audubon's Shearwater (*Puffinus lherminieri*) is not to be found among them.

The cranium marked "*Æstrelata lessoni*," No. 14494, U. S. Nat.

[7] Shufeldt, R. W., "On the Osteology of the Tubinares," *Am. Nat.*, Vol. XLV, No. 482, Feb., 1907, fig. 1, p. 116.

Mus. Coll., collected by Doctor Kidder (see list above), agrees, in all essential particulars, with the cranium figured by Forbes, as set forth above; doubtless the former came from a specimen of that species, as did likewise the latter. The mounted skeleton from the Museum of Comparative Zoölogy, marked *Æstrelata lessoni*, is not a skeleton of that species, but evidently belonged to some medium-sized Shearwater (*Puffinus*) of a somewhat larger size than *Puffinus lherminieri*. It came from a bird of about similar proportions to the one marked *Puffinus obscurus* of the collection of the U. S. National Museum (No. 17724). The skulls are of the same size and very much alike; but the National Museum specimen had a somewhat longer humerus and a shorter sternum. The species—whatever it was—is not represented in the Bermuda specimens at hand for description.

Æstrelata lessoni is a large, rather heavy Petrel of about the same proportions as *Fulmarus glacialis*, and its skull agrees in many particulars with that species. (Compare with No. 16781, Coll. U. S. Nat. Mus. = *Fulmarus glacialis*.)

Finally, I have compared all the Bermuda specimens with the material in the above list, representing the osteology of the *Tubinares* in the collection of the U. S. National Museum, including even *Procellaria cooki* (Pl. XIX, fig. 17) and *Pelecanöides urinatrix* (Pl. XX, fig. 21). Most of this material is likewise figured on the plates; and, as far as it goes, it demonstrates very completely that none of the species are to be found among those from Bermuda, as represented by the bones at hand.

I now pass to a description of the material itself—the subfossil bird bones from Bermuda.

This, as pointed out above, is divided into three (3) lots, and may be designated as:

1. The Mowbray collection.
2. The McGall collection.
3. The American Museum of Natural History collection.

1: In the Mowbray collection the bones are very fragile; have more of the cave incrustation upon them; and are, as a rule, not nearly as perfect as those in the other two lots. It contains no skulls, only a parafin cast of one of the "Cahow" skulls found in the other two collections. The piece of the upper mandible with the theca still upon

it has already been described on a former page. There are 4 humeri in fairly good condition; 2 nearly perfect ulnæ, also 2 ossa quadrata. All of these bones belong to the "Cahow," and need not be referred to especially again, as there is ample duplicate and far more perfect material in the other two collections for the purposes of description.

2: This is the most extensive collection of the three; not only does it contain a large representation of the bones of the "Cahow" in excellent condition, but also the *sternum* of a new species, and a lot of bones representing some smaller tubinarine form—both of which, together with the "Cahow" bones, will be described in detail further on.

3: We have here a smaller collection than the last (No. 2), though withal a most interesting and perfect one. It is chiefly made up of the bones of the "Cahow," and of some very important ones of the more diminutive tubinarine species referred to as being found in the McGall collection. It will, on the whole, very materially contribute to the working up of the specimens before me.

I shall first describe the unique *sternum*, referred to as forming a part of collection No. 2.

Puffinus mcgalli, sp. nov.

(Plate XXII, fig. 29, and Plate XXIII, fig. 36.)

[Recent Epoch.]

Based on an almost perfect *sternum* of an adult individual discovered in the bird-bone caves of Bermuda.

The specimen indicates that it belonged to a species of *Puffinus* of moderate size, and probably possessed characters typical of the genus. Judging from the sternum sent me by Mr. Maynard (see *antéa* and the plates), it was a considerably larger bird than *Puffinus lherminieri*, as the length of that bone in the first measures—from the anterior tip of the manubrium to the extreme posterior point of the mid-xiphoidal process—5.8 cms., while in the latter this line or distance equals but 4.4 cms. From apex to apex of the "coracoidal processes," *P. mcgalli* measures 3.3 cms. and *P. lherminieri* but 2.5 cms. Either of these sterna possesses six articular facets on each costal border for the costal ribs. Upon comparing this sternum with the sternum of "*Puffinus major*" (No. 18076, Coll. U. S. Nat. Mus.), the latter is seen to be a species very considerably larger than the one here being described. I have also compared it with the sterna

of *Puffinus creatopus, P. borealis, P. griseus,* and others, but it departs more or less from each and all of them.

There is a trunk skeleton of a Shearwater in the collection of the U. S. National Museum (No. 19385) marked "*Puffinus gavia,* San Diego, Cal." Sharpe, in his "Hand-List" (Vol. I, p. 124), restricts the range of this species to "New Zealand and Australia"; it is not listed in the A. O. U. Check-List (1910).

This "*P. gavia*" was a bird of almost exactly the same size as *Puffinus mcgalli,* and its sternum, measured as above, has a length of 5.6 cms., while its width, measured as above, equals 3.45 cms.

McGall's Shearwater possessed a pair of deep "notches" upon either side of the keel, the outer one, on either side, being double the width or more of the one between it and the mid-xiphoidal prolongation. This is likewise the case in the sternum marked *Puffinus gavia* of the National Museum collection (No. 19385).

The very small manubrium in McGall's Shearwater is longitudinally keeled upon its median ventral aspect, while the ventral edges of the coracoidal grooves are carried out upon it laterally to points near its blunt apex. The *coracoidal grooves* are extensive, and they do not meet in the median line behind the manubrial process.

The bone is non-pneumatic, and dorsally the body is profoundly concaved, being correspondingly convex upon its ventral aspect.

Unfortunately, the anterior *carinal angle* of the keel is broken off and lost; but there is no question as to the form it had in life, for it doubtless agreed with what we find in all other Shearwaters of this genus—that is to say, it is somewhat produced anteriorly, expanded from side to side to some considerable degree, compressed from above, downwards, and has, in the articulated skeleton, the os furculum resting upon it. The anterior border of the carina of this Shearwater is thickened above, gradually tapering to the carinal angle below; longitudinally, from above, downwards, it is marked by a well-defined groove.

Costal processes are broadly quadrilateral in outline, and each one rises to a moderate height above the costal groove of its own side. Either costal groove has a length of 1.8 cms., there being five (5) quadrilateral concavities formed by the six (6) transverse, thin, articular facets upon either side.

The lower border of the keel is nearly straight, and it is continued

to the extreme posterior end of the mid-xiphoidal process, gradually diminishing in depth for its entire length. The xiphoidal processes have already been described above.

On either side, posterior to the costal border, the margin of the bone is very thin and sharp. On the ventral aspect of the body the "pectoral line" is very distinct, either one being carried from a mid-point below the coracoidal groove backwards and inwards to a point next to and about at the middle of the keel.

This extinct species is named for Mr. Edward McGall, in recognition of his success in obtaining this valuable collection of fossil bird-bones from Bermuda.

Puffinus parvus, sp. nov.

(Plate XXIV, figs. 43–45; Plate XXV, figs. 55, 56; Plate XXVI, figs. 67, 74, 76, 77, and 79; Plate XXVII, fig. 93, and Plate XXVIII, figs. 101, 107, 121, 122, and 123.)

[Recent Epoch.]

Among the bones in the collection of the American Museum of Natural History, as well as among those in the McGall collection, I find abundant evidence pointing to the fact of the existence of a small Shearwater, now extinct, but which doubtless existed during the times when the countless numbers of the "Cahow" flourished upon certain of the smaller Bermudan islands.

In the first-named collection, there are of these bones a cranium (somewhat imperfect), an ulna, a radius, a carpometacarpus, part of a sternum, four ossa innominata, a femur, a tibiotarsus and a tarsometatarsus; in the latter collection, five perfect humeri, three ulnæ, a radius, a carpometacarpus, a proximal joint of index digit, a coracoid, an inferior mandible, an imperfect os furculum, a tarsometatarsus, and an os innominatum of the left side.

These bones indicate a Shearwater (*Puffinus*) smaller than Audubon's Shearwater (*Puffinus lherminieri*)—that is, smaller than any Shearwater in our present Atlantic Ocean avifauna. It was a smaller *Puffinus* than the one shown in Plate XXIX, fig. 126, of the present paper.[8]

[8] Upon comparing a number of the bones of this extinct Shearwater with the corresponding ones in the mounted skeleton from the museum referred

Clearly, then, in so far as skeletal material representing Audubon's Shearwater (*P. lherminieri*) is concerned, I have at hand but the sternum and shoulder-girdle from the Maynard collection and the disarticulated skeleton of a "*Puffinus obscurus*" (No. 17724, Coll. U. S. Nat. Mus.) to use as representing that species; the value of these will be touched upon further on.

Upon comparing the cranium of this small Shearwater belonging to the collection of the American Museum of Natural History, I find that it essentially agrees in all particulars, apart from the matter of

to, I find that, apart from the matter of size, they possess identical characters. This applies especially to the mandible, the humerus, the radius and ulna, the carpometacarpus, the pectoral arch, the os innominatum, and the bones of the pelvic limb. The extinct bird had a short sternum, however, as in *Puffinus creatopus* and other species, while that bone in the aforesaid mounted skeleton is of the elongate variety, as in *Puffinus major* and others.

There is no doubt about this mounted skeleton from the Museum of Comparative Zoölogy of Harvard University having belonged to a Shearwater (*Puffinus*) of rather small size, though typical of the genus. It was probably incorrectly identified at Ward's Natural Science establishment at Rochester. A paper envelope is attached beneath its stand, in which there are two of the usual printed Ward's labels. In filling in the name in writing on each of these, an error was made in either instance. In one it reads: "Procellaria Lessoni (White-headed Petrel). East coast, New Zealand," and in the other: "Procellaria Lessonii (White-headed Petrel), New Zealand." No further comment is required.

[9] This cranium, when sent to me with the collection, was carefully packed in a small box by itself and placed *under* all the other packing for all the other bones. Owing to this fact, I did not discover its presence until I came to repack the collection for its return to the Museum, when much to my surprise, it was in the bottom of the original box, hidden from sight by a great quantity of "imperial" or "excelsior." Had I had it with the rest of the bones, it would have been duly figured upon one of the plates; as it is, Figs. 6 and 16 will have to stand for it, only they are somewhat larger. I would take this cranium to be one that belonged to an Audubon's Shearwater—it being either a female or a subadult individual—were it not for the fact that all the other bones in the combined collections, representing *Puffinus parvus*, evidently belonged to a number of different specimens, *all* of which were adult, and *all* smaller in proportion, as compared with the corresponding bones in *Puffinus lherminieri*. Indeed, this skull coming to light in the way it did, and at the time it did, convinces me all the more that, when Audubon's Shearwater and other allied forms were to be found on the Bermudas in enormous numbers, there was also present there this smaller form,—that is, *Puffinus parvus*. (Dec. 10, 1915.)

size, with the cranium of Audubon's Shearwater (Pl. XVI, fig. 6; Pl. XVIIII, fig. 16).[9] It has the same well-marked median furrow on the superior aspect between the frontals posteriorly, and the same, very narrow though rather deep, supraorbital glandular depressions—which are only separated from each other by 2.5 mm.—in the frontal region between the orbits on the top of the cranium.

The superior mandible is slender and the external narial apertures elongate and narrow. Distally, it is decurved, especially enlarged, and ends with an acute, sharp-pointed apex. The interorbital septum presents unusually large vacuities, and the *pars planæ* are very small, projecting outwards in each case as an independent process. With but slight departures, the characters seen in the osseous structures of the basis cranii are the same as we find them to be in all Shearwaters, and more or less like the corresponding ones in a Petrel of the genus *Æstrelata*. Longitudinally, from the most posterior point in the median line of the supraoccipital prominence to the distal apex of the premaxillary, this cranium measures 6.4 cms., and the transverse diameter, between the tips of the postfrontal processes, equals in width 2.35 cms. In short, this cranium belonged to a small species of a typical *Puffinus*.

Coues gives the length of the tarsus, in the case of *Puffinus audubonii*, as 1.60 (or an inch and six-tenths) (Key, 5th Ed., p. 1036), while the tarsus in the species here being described has a length of but 1.50, or even less in the case of a specimen of that bone found in the McGall collection. It was a much smaller species than the one which furnished the skeleton marked "*Puffinus obscurus*" in the collection of the U. S. National Museum (No. 17724), and Audubon's Shearwater was possibly the *Puffinus obscurus* of Gmelin, certainly so of Coues and other ornithologists of a few years ago. It then became *P. auduboni* of Finsch (P. Z. S., 1872, p. 111). So, the skeleton just referred to (No. 17724) being that of a *very small* Shearwater, it brings the matter to a point where Mr. Maynard would have to show that the sternum and shoulder-girdle he sent me belonged to a specimen of Audubon's Shearwater, now called *Puffinus lherminieri* in the last A. O. U. Check-List. It is a very different sternum from the one belonging to the aforesaid museum (No. 17724), and a much larger bone—too large, it strikes me, for the sternum of Audubon's Shearwater (*Puffinus lherminieri*). If the

skeleton numbered 17724 (*"P. obscurus"*) in the collection of the U. S. National Museum is in fact Audubon's Shearwater, then the species here being described is *certainly* a new species as well as an extinct one. Mr. C. Maller collected the specimen of *"Puffinus obscurus,"* No. 17724, and he collected it at the "Bermudas." This still further emphasizes the fact that it probably represents the skeleton of an Audubon's Shearwater, and that it was a larger species than the one here being considered. The metatarsal bone in No. 17724 measures in length exactly 1.60 inches, and this agrees with the length of the tarsometatarsus of Audubon's Shearwater as given by Coues and set forth above. With all this evidence and these facts before me, I shall consider for the present that the skeleton No. 17724 is one of *Puffinus lherminieri*, and use it in comparison in the present instance. This will not militate against anything I have set forth above in regard to McGall's Shearwater (*P. mcgalli*), or the use I made of the sternum and shoulder-girdle sent me by Mr. Maynard.

Taken together, and judging from the material before me, the bones representing *Puffinus parvus* probably belonged to three different adult individuals. That this may have been the case is based on the fact that there are in it *five perfect humeri*, or those belonging to *two* specimens and one of a third. There are *two pairs* of tarsometatarsi, two pairs of ulnæ, and so on. Had there been one less humerus, I should have said that the bones in the combined collections represented *two* adult specimens of *P. parvus;* but the fifth humerus makes it possible that three or more may be represented.

The *mandible* of *Puffinus parvus* is of the V-shaped pattern, with the narrow dentary portions drawn very close together—the symphysis being short and the distal apex sharp-pointed and slightly decurved. There is a small ramal vacuity in the deeper ramal divisions, the side of the jaw upon either hand curving upwards and forwards where it is located. Posteriorly, the articular ends are concaved and very slightly truncated. Mesially, the articular cups for the quadrates support the usual inturned apophyses, with the pneumatic foramen at the apex of each. The extreme length of one side of this mandible measures 5.4 cms.

Turning to the mandible of the specimen of *"P. obscurus"* (No. 17724), I find the characters to be much the same, although there are slight but recognizable differences here and there. For example, the

ramal vacuity is reduced to a mere hair-like slit, and so on. It measures in extreme length 5.9 cms., and so belonged to a larger bird than *P. parvus*.

Os furculum is of the U-shaped pattern, the clavicular limbs being slender and of nearly uniform caliber throughout their lengths. There is a faint hypocleidium on their somewhat thickened union below; it is situated posteriorly and amounts to little more than a low, thin line of bone. The free posterior extremities above are drawn out into sharp-pointed endings, and there is an articular facet on the outer side of each at a few millimeters' distance, posterior to the apex. Such a fourchette is well seen in my figure of *Procellaria cooki;* but in this species the free extremities are not drawn out so far, and the articular facets for the coracoid is better marked (Pl. XXIV, fig. 17). Compare figs. 61, 62, 68, 69, 70, 78, and 79 of Plate XXVI.

There is a perfect *coracoid* (left) of *Puffinus parvus* in the McGall collection (fig. 92, Pl. XXVII), which presents all the characters of that bone as we find them in any coracoid of a typical Shearwater. The axis of its shaft measures 2.3 cms., and the transverse diameter of its sternal extremity 1.55 cms. There is a conspicuous precoracoid process that exhibits a foraminal perforation at its lower part near the shaft. The latter is non-extensive and much compressed antero-posteriorly. With the somewhat prominent acromium, the precoracoid forms, mesiad, a vertically elongate valley of considerable extent, opposite which, on the other side of the bone, the glenoid cavity is seen to be elongated vertically and very shallow.

In the collection of the American Museum of Natural History there are two fragments of a *sternum* which evidently belonged to this extinct Shearwater. These fragments consist of the anterior portion of the bone, and a large part of the left half of the sternal body. They did not belong to the same individual, though to one of similar size; both were adult birds. Barring the difference in size, this sternum of *Puffinus parvus* possessed a form very much like the sternum as we find it in *Puffinus major* (see Pl. XXIII, fig. 38). The manubrium is small and peg-like, and the "coracoidal groves" meet mesially. Ventrally, the thoracic concavity is unusually deep and capacious, a single pneumatic foramen being present in the middle line well within the anterior border of the bone. As usual in *Puf-*

finus, there are six (6) hæmapophysial facets upon either costal border, the well-marked concavities among them being nearly square in outline. The external xiphoidal processes were broad, and extended outwards as much as backwards—more so even than in *Puffinus major.*

No *sacrums* of this bird were collected, while a lateral moiety of a *pelvis* possesses all the characters, barring size, which we find in any typical *Puffinus,* as, for example, *P. lherminieri* or *P. major.* (Compare fig. 64, Pl. XXVI, and figs. 85–89, Pl. XXVII.)

Ilium has a length of 4.1 cms. in *P. parvus* and 5 cms. in *P. lherminieri,* while in *P. major* the length is 7.6 cms.;[10] some are a millimeter shorter—probably belonging to female individuals.

There may be some vertebræ among the numerous examples of those bones set aside as belonging to the "Cahow" (*Æ. vociferans*); but I can not pronounce upon that with certainty, as they may be ones belonging to either young or female "Cahows."

Five beautiful specimens of the humerus of *P. parvus* occur in the collection of Mr. McGall, and they each and all belonged to adult birds (figs. 55 and 56 of Pl. XXV). Four (4) of these bones possess a length of 5.9 cms., while the fifth measures but 5.75 cms., and may have belonged to a female bird. Its characters are identical with the corresponding ones in a humerus of Audubon's Shearwater, the latter being a longer and a trifle larger bone. (Compare figures 51–60 of Plate XXV.)

In all Shearwaters the humerus appears to be completely non-pneumatic, the shaft being very straight and more or less compressed in the same plane in which the extremities occur—that is, from anconal to palmar superficies. The "ectepicondylar process" is pointed and is a conspicuous feature of this humerus, while the triangular radial crest is bent, as a whole, towards the palmar side of the bone.

[10] While examining the bones of *Puffinus parvus* I met with several fragments of an interesting shell, the most perfect of these being in the collection of the American Museum of Natural History; four (4) of the other fragments occur in the McGall collection. They are all of the same species, and have been identified for me by Dr. Paul Bartsch, of the U. S. National Museum, as being broken examples of five specimens of *Poecilozonites bermudensis,* Pfr. Doctor Bartsch kindly compared them with specimens in the collection of the U. S. National Museum.

Ulna and *radius* present nothing peculiar beyond their size, being smaller than any bones of the antibrachium that I have ever examined belonging to a typical *Puffinus* (Pl. XXIV, figs. 44 and 45). The *ulna,* as in the case of the humerus, exhibits some slight lateral compression, such as we find in other Shearwaters of existing avifaunæ. The *radius* has a length of 5.4 cms. and is nearly straight.[11]

Bones of the carpus (*radiale* and *ulnare*) do not occur among the subfossil bones in these collections; they doubtless would be almost identical with those elements as we find them in the wrist of any small, typical Shearwater of the genus *Puffinus.*

Carpometacarpus is straight and possesses a length of 3.3 cms. (Pl. XXVI, fig. 67), while that bone in Audubon's Shearwater has a length of 3.6 cms. (Pl. XXVI, figs. 76, 77). There is a specimen of an imperfect carpometacarpus of *Puffinus parvus* in the American Museum collection, which has a length of but 3 cms., but it belonged to a subadult individual, and plainly shows the divisional lines of the added elements at its proximal end.

Proximal phalanx of *index digit* of this extinct species of Shearwater (fig. 74) agrees better in the matter of form with that bone of the skeleton in some of the larger Shearwaters than it does with that of *P. lherminieri,* though only in the matter of being very slightly wider for its length (figs. 71–73). In other respects it agrees in its morphology with that segment of the hand in *Puffinæ* generally.

There may be some terminal finger joints of *Puffinus parvus* in these collections, but they may have belonged to female or subadult specimens of the "Cahow"; so I pass them by. The lists show that a considerable number of these bones are present.

Upon comparing all the bones of *manus* shown in Plate XXVI, figs. 65–67, 71–77, and 80–84, one can gain a very correct idea of the size and characters of that part of the skeleton in *P. parvus* as compared with the corresponding parts in other Shearwaters of various sizes; such comparisons render it quite unnecessary for me to enter upon minutiæ in the matter of character descriptions of the hand-

[11] Some of the bones on the plates may run somewhat longer or be otherwise larger than is stated in the text. This may be due to my having made them so with the camera and the engravers reproducing them exactly, or to the engravers not getting them the same size as the originals; in any event the sizes and lengths as given in the text are to be relied upon.

bones of the extinct species. This remark also applies to the phalangeal joints of the feet.

Turning the attention next to the lower or *pelvic limb,* several of the long bones are present, the number of them being set forth in the various lists above. (Compare the bones of the different species of *Puffinus* shown on Plate XXVIII.)

A perfect femur of *P. parvus* occurs in the collection of the American Museum of Natural History; it agrees in all respects with the femur of Audubon's Shearwater, as shown in figs. 102 and 103, even to the remarkable bending or bowing of the continuity of the shaft at the juncture of middle and lower thirds. In length it measures two and a half centimeters.

Femora of other Shearwaters are well shown in figs. 104 and 105, as well as in 112 and 113. The shafts of these are not bowed quite as much as in the smaller species; while in the Petrels of the genus *Æstrelata,* whether living or extinct, this bone is not bowed at all, but has a straight shaft as in the extinct Petrel, *Æstrelata vociferans* (figs. 97–100). This is an excellent differential character in proving that the "Cahow" was an *Æstrelata* and not a *Puffinus,* as has long been supposed to be the case.

The *tibiotarsus* of *Puffinus parvus* presents all the characters of that bone, as we find them in existing representatives of that genus of birds. These characters are well shown in figs. 118–120, as compared with the tibiotarsi of other Shearwaters illustrated on the same plate (XXVIII). One of the most striking characters is the enormously developed cnemial process. Comparatively speaking, this is even larger than we find it to be in the big birds of the group, as *Puffinus major* and others. Moreover, this great cnemial extension is not to be found in Petrels, in so far as I have examined them, certainly not in the extinct "Cahow" or *Æstrelata vociferans.* All have the shaft of the bone very straight, however, and this is likewise the case with such forms as *Procellaria cooki* and *Pelecanöides urinatrix,* which birds have the cnemial extension of the tibiotarsus reduced as we find it in *Æstrelata.* (See figs. 20 and 24 of Pls. XIX and XX, respectively.)

As in all small and typical Shearwaters, the *tarsometatarsus* of *Puffinus parvus* was long and comparatively slender (figs. 106 and 107, Pl. XXVIII), it being relatively shorter and stouter in the

Petrels. This is another excellent distinctive character between *Puffinus* and *Æstrelata*. The bone in *P. parvus* is remarkably straight and slender, being longitudinally grooved for tendons both anteriorly and posteriorly, more markedly so in front. The intercondylar eminence is prominent, and the condylar cavities upon either side of it are deep and circular in outline. The *hypotarsus* is short, the inner section of it being twice as long as the outer, which latter is once pierced for tendinal passage. A similar passage is to be found between the two sections, but it is not quite closed posteriorly.

Middle third of the shaft is somewhat compressed from side to side; indeed, the entire bone shows something of this transverse compression—even the trochleæ of the distal extremity. With respect to these, the middle one is the longest, the outer next in length, and the inner one of the three the most elevated. Rather high up on the outer side, we note the usual foraminal perforation for the passage of the anterior tibial artery. The shaft of the bone, proximally, is also twice pierced in the antero-posterior direction, just below the head, as we find it to be in nearly all birds.

I have given this new and extinct form of Shearwater the specific name of *parvus* for the reason that it is probable that, when the species was in existence, it had few, if any, members in the same genus that were smaller than it. The name *Puffinus* was an attempt on the part of the early writers upon ornithology to latinize the word *puffin*. Very early in ornithological history and literature *Fratercula arctica* and its near allies were called *puffins*, for the reason that, when they squatted down upon the rocks where they lived, they appeared to be *puffy* or puffed up—hence "Puffin." Shearwaters at that time were also called "puffins," as they were frequently observed in the same localities. However, the vernacular term was soon dropped in their case, while the early writers, in looking up the scientific name for them, hit upon *Puffinus* as a justifiable way in which to perpetuate the name *puffin*, without being really guilty of confusing them with the true birds bearing that appellation (*Puffininæ*).

Æstrelata vociferans,[12] sp. nov.

(Extinct.)

["Cahow"; Bermudan Cahow; Noisy Petrel.]

As set forth on previous pages of the present memoir, the material upon which this new species is based is remarkably abundant, for which science can thank the painstaking labors of Mr. Edward McGall, who collected it in the Bermuda caves.

It has long been a question among ornithologists as to whether the famous "Cahow" was a Shearwater (*"Puffinus obscurus"* ?) or a Petrel (*Æstrelata*). In so far as my observation carries me, there is at least one character in the skeleton by means of which we can, with certainty, distinguish from each other these two different kinds of birds. This character is seen in the form of the *cnemial process of the tibiotarsus.* In the genus *Puffinus*—and possibly in some of its near allies—the cnemial process of the tibiotarsus is conspicuously elongate, as we see it in the Grebes and Loons; while in the Petrels it is notably shorter, with rounded superior margin. These differences are well shown in the bones figured on Plate XXVII (figs. 116–125, inclusive). Judging from this character, too, such forms as *Pelecanöides urinatrix* and *Procellaria cooki* are more closely related to the Petrels than to the Shearwaters of the genus *Puffinus* (see Plate XIX, fig. 20, and Plate XX, fig. 24). Judging from this character alone, there is no question but that the "Cahow" of the Bermuda Islands was an *Æstrelata* and not a *Puffinus.* This fact is sustained by other osteological as well as external characters found in the representatives of the two genera in question. For example, both the horny sheaths to the mandible, as well as those parts in the dried skulls when deprived of the sheaths, are positively diagnostic

[12] *Æstrelata,* the generic name for these petrels, is here retained, as it is so spelled in the A. O. U. Check-list. Nevertheless, it is incorrect, and perpetuates a blunder in orthography, for which Charles Lucien Bonaparte is responsible. More correctly, the word should be spelled *Œstrelata.* Prince Bonaparte would be highly complimented were it possible for him to know that an ornithological committee of high standing, in the twentieth century, stood, in cold blood, for what was probably a *lapsus calami* of his.

Vociferans (sp. name), Latin: the participle *vociferans* from *vocifero* (*vox,* gen. *vocis,* voice + *fero,* I bear); hence, noisy, vociferous; here bestowed upon this bird as it was known in life to be a very noisy species.

with respect to these two groups of tubinarine birds. The differences in the external forms of the beaks are well shown in figs. 128–130 of Plate XXXI of the present contribution, fig. 128 giving the beak of a typical Shearwater, and figs. 129 and 130 those of Petrels of the genus *Æstrelata.* I am of the opinion that *Æ. vociferans* was closely related to *Æ. caribbæa* (fig. 129), as I have attempted to show upon a previous page of this memoir.

The differences in the osseous mandibles of a Petrel (*Æstrelata vociferans*) and a Shearwater (*Puffinus lherminieri*) are easily appreciated upon comparing those parts in figs. 5 and 6 of Plate XVI. All Petrels and petrel-like birds possess osseous beaks or mandibles, such as we find figured in figs. 1–5, Plate XVI; in fig. 11 of Plate XVIII, as well as in Cook's and the Diving Petrels.

The *tarsometatarsus* is generally long and slender in the petrel forms; shorter and stouter in the Shearwaters. (See the various figures of this bone on the plates.)

The "Cahow," then, was a Petrel of the genus *Æstrelata;* and with this point settled, I can proceed to give an account of its skeleton.

Osteology of *Æstrelata vociferans.*

The Skull (figs. 1–5, Pl. XVI).—This now extinct Petrel was, in life, morphologically typical of the procellaridine genus to which it belongs, for the subfossil bones at hand in such abundance are ample proof that it was osteologically so; consequently, the remainder of its anatomy must have been in keeping with the characters so clearly in evidence in its skeleton. The *skull* as a whole, apart from its smaller size, essentially agrees in all particulars with the skull of *Æ. lessoni,* as figured by Forbes in his Challenger Report on Petrels, cited on a former page of the present work. The *hyoid arches* are here missing; but it is more than safe to predict that they, too, agreed with those elements as found in other species of this genus.

Viewed from above, we are first to note, in this skull of *Æstrelata vociferans,* the twin elevations of the *parietals,* with a well-marked median and rounded groove between them. In some skulls this latter is carried forward faintly to the "cranio-facial hinge." Generally it is deepest at a midpoint between the orbits, where the superficies between the *supraorbital glandular depressions* most nearly approach

each other. These latter have an average width of 4 mm. and are most conspicuously excavated. Either one extends from the lacrymal of its own side to the prominent postorbital process behind. These glandular depressions are a striking feature of the dorsal aspect of the skull in all the Petrels known to me, as well as in the Shearwaters and other sea-fowl.

The frontal region of the skull under consideration is broad and extensive; mesially, in the depression over the naso-premaxillary part, is to be noted the persistent remains of the frontal processes of the premaxillary. This is present in all eight of the skulls of *Æstrelata vociferans* before me. This character is seen in most, if not in all, Shearwaters of the genus *Puffinus,* and faintly so in *Daption.*

Between the external narial apertures the culmen is very narrow at its middle, but slightly expanded anteriorly and posteriorly. Either *narial aperture* is elongate, narrow, and elliptical in outline. This form of opening, then, is as much rounded behind as it is in front; so that the term "schizorhinal" is hardly applicable to a skull thus characterized.

Beyond the narial apertures the superior mandible is elegantly arched upwards, being bounded on either side posteriorly by the grooves continued forwards from the narial openings, and extended downwards at the apical extremity into a sharp-pointed tip. (Fig. 5, Pl. XVI.)

Passing to a direct *posterior view* of this skull, we are to note the curious form of the *postfrontal processes,* each standing out from the side of the skull in such a way as to resemble a small ear, marked on its hinder surface by the extension forwards of the crotaphyte fossa of the same side. These *crotaphyte fossæ* are most conspicuously excavated, though they do not meet over the unusually large "supra-occipital prominence" posteriorly. Their margins are sharp and to a slight extent elevated, especially the inferior ones. Supraoccipital foramina are not present in this skull; neither do we find those openings in the skulls of the *Puffininæ* nor in the Fulmars. Indeed, the rear view of the skull of this extinct Petrel here being considered closely resembles the same aspect of the skull in most species of *Fulmarus.*[13]

[13] Shufeldt, R. W., "Contributions to the Comparative Osteology of Arctic and Sub-arctic Water-Birds." Part I, *Journ. of Anat. and Phys.,* Lond.,

Turning to the lateral aspect of the skull in hand, it will be observed from fig. 5 of Plate XVI that the "interorbital septum" exhibits large vacuities in it, both centrally and above; though in most skulls of this species the *foramen rotundum* is entire—that is, surrounded by bone.

While protected posteriorly by the flaring *os squamosum*, the entrance to the ear is much exposed in front, affording the opportunity to fully examine its interior structure and the articular facet for the *os quadratum*. Anteriorly, the large quadrilateral *pars plana* is thoroughly coössified for its entire outer boundary and above with the big *lacrymal bone*, and the latter likewise, superiorly and anteriorly, with the frontal and nasal of the same side. Here is a point that at once distinguishes the skull of this extinct Petrel from the skull of a Shearwater of the genus *Puffinus;* for in the latter group we always find the *lacrymal bone* to be a free element which promptly comes away during the process of maceration. In *Æstrelata* it is deeply grooved antero-posteriorly at its middle, and in this groove we always find a large, circular, pneumatic foramen, the bone extending outwards and backwards just below it. *Daption capense* has a lacrymal and a *pars plana* essentially agreeing with what I have just described for the subject in hand.

Between the lacrymal and the posterior sharp edge of the *nasal* of the same side no bony wall exists; so that, when viewed upon this direct lateral aspect, one can look *through* the skull over the broad vomer below, as is well shown in fig. 5 of Plate XVI; in other words, the midposterior part of the rhinal chamber is entirely lacking in osseous, protecting, lateral walls.

At the side of the *superior osseous mandible* beyond this the surface is extensive and smooth, with its lower tomial edge cultrate to the apex beyond.

A *quadrate bone* has a broad orbital process, with a markedly truncate extremity; and at the base of this, internally, we always find a single, circular, pneumatic foramen of some considerable size. Above the articular head has two very independent articular facets, each of an ellipsoidal form—the outer being the larger of the two.

Oct., 1888, XXIII, n. s., Vol. III, Pl. II, fig. 8. Other skulls or marine bird-forms are figured in this part of the work in question, which can be compared with the skull of our Petrel with advantage.

The articulatory surface for the mandible is irregular in contour and extensive. The body of the bone, including the orbital process, is greatly compressed transversely.

I find no pterygoids in either of the collections at hand, but it is not difficult to conceive what they were like.

The *quadrato-jugal* or *infraorbital bar* is extremely slender, and continues to be so until it joins the triangular, horizontally disposed *maxillary* anteriorly. Its inturned articular nib for the quadrate, at its free, posterior end, is very small.

Posteriorly, the *basis cranii* is bounded by the semi-circular line of the occipital crest, here forming the lower boundary of the crotaphyte fossæ.

In some of these skulls the *foramen magnum* is almost circular in outline, while in others it is distinctly cordate, the *occipital condyle* being unusually small for a bird having the size that *Æstrelata vociferans* had, while its center, posteriorly, may or may not exhibit a faint notch.

The small foramen above and on either side of the foramen magnum has a deep though narrow groove running forwards from it, to be lost on the basitemporal, between the occipital condyle and the wing of the *os squamosum*. This pair of groovelets are very distinctive of the skull in Petrels and Shearwaters, and less in some other tubinarine birds.

The *basitemporal* region is smooth, nearly level, and triangular in outline; while beyond its anterior apex are to be observed the pair of small, sessile facets, one on either side, for the pterygoids. Between these and the posterior, articular extremities of the palatines is to be seen the inferior rounded surface of the sphenoidal rostrum, which is exposed for a distance of several millimeters (fig. 4, Pl. XVI).

The large *vomer,* with its decurved, pointed, anterior extremity, fuses with a palatine upon either side, although these latter bones do not anchylose together for their hinder moieties. Either bone, for its latter or posterior half, has its internal and external margin raised, while the dorsal aspect is developed as a scroll-like elevation. Beyond, the *prepalatine* is much flattened in the horizontal plane, well separated from the fellow of the opposite side, while most distally it

turns outwards to fuse with the inner side of the superior mandible (fig. 4).

The short, scroll-like *maxillo-palatines* do not meet in the middle line, nor do they come in contact with the anterior free extremity of the vomer. Such part of the roof of the mouth as lies beyond the palatines and between the sides of the *premaxillary* is not spanned by bone, thus allowing an uninterrupted view of the interior of the fore part of the rhinal chamber.

As one would naturally suppose, the *medio-stapedial element* of the middle ear, and the *sclerotal plates* of the eye, are, for very obvious reasons, not to be found among the bones of these two collections.

The *mandible* has the typical V-shape pattern, with the sides of the anterior dentary portion low and thickish. The symphysis is very short, while the apex of the enlarged distal extremity is acute and decurved. It is longitudinally grooved dorsally. For the posterior ramal portion, we find the side thin and lofty, with the superior margin sharp and the lower one rounded. No "splenial vacuity" is present in fully adult birds, while posteriorly, on the mesial aspect, there is considerable excavation or concavity just anterior to the enlarged articular posterior extremity. This latter is concaved and truncate on its posterior aspect; double-concaved dorsad, to accommodate its surface to the quadratal articulation, and its inturned part, on this upper side, showing the minute, pneumatic foramen usually found in that situation.

The Vertebral Column.—When Forbes came to study the Petrels collected by the naturalists of the Challenger Expedition, as cited on a previous page, he found, in a specimen of "*Œstrelata grisea*" that there were fifteen (15) *cervical vertebræ*, seven (7) dorsals, eleven (11) sacrals, and seven (7) caudals, making forty (40) in all. As he does not mention the *pygostyle*, I presume he simply considered it as the ultimate or terminal caudal.[14] He also found that in "*Œstrelata grisea*" there were eight (8) pairs of vertebral ribs—that is, one cervical pair and seven (7) dorsal, or ribs joining with the costal ribs below. The dorsal ribs supported *epipleural appendages*, with

[14] He also examined another Petrel, which I am inclined to believe was not an *Œstrelata grisea* (*b*), and he seemed to doubt the correctness of the identification. It had forty-one (41) vertebræ in its spinal column (*loc. cit.*, p. 419).

perhaps the exception of the last pair, and there was probably a pair of free *cervical ribs*.

The vertebræ and ribs in the collection of the American Museum of Natural History do not fully admit of completing the chain, in order to assemble a perfect skeleton of *Æstrelata vociferans*, while they do in the collection of Mr. McGall. After very careful study, I have selected from the latter lot a string of vertebræ that I must believe are very nearly, if not quite, correct. They may, of course, have belonged to a number of different individuals, and are probably of both sexes at different ages; but this is the very best one can do with such a mixed lot of material. In my own mind there is no question but that the *number of vertebræ* in the spinal column of the extinct Petrel here considered agreed with "*Œstrelata grisea*," as enumerated above; so, too, for the *ribs*. One thing is certain: both species possess *eleven* vertebræ in the sacrum. Then I selected the *cervico-dorsal* series *before* I turned to the work of Forbes on *Œstrelata grisea*, and very much to my satisfaction I found that I had settled upon the same number of *cervicals* and *dorsals* that he had entered in his table—that is, 15 cervicals and 7 dorsal vertebræ. The arrangement is precisely the same throughout—ribs, epipleural appendages, and all—in *Ossifraga gigantea* as it is in the true petrels, but not in any of the rest of the *Procellaridæ*, in so far as Forbes and I have examined them.

The *atlas* is very delicately fashioned, its body being incomplete above, the remaining parts either thin or small, and the bone is unmarked by any passage on either side for the vertebral arteries. This is also the case with the *axis*, in which vertebra the odontoid process is short and feebly developed. It has, however, a well-pronounced hæmal and neural apophysis, and its diapophyses are turned abruptly upwards.

We find that the *third cervical vertebra* also possesses strong neural and hæmal spines, while perfect canals for the vertebral arteries are present in it, and short pleurapophyses project backwards from beneath them, one upon either side. These are longer and more spiculiform in the *fourth cervical*, and in this the pre- and postzygapophyses are an evident feature. Its neural and hæmal spines are on the road toward aborting. From this point on, to include the 15th vertebra which supports a pair of free ribs, the vertebræ of this division of

the column become gradually broader and broader; the neural spines disappear completely; the very short pleurapophyses are extremely delicate, while the passages for arteries, both ventrally and laterally, are much as we find them in the Petrels generally.

All seven of the *dorsal vertebræ* support oblong neural spines, while the hæmal ones, although present in every case, are best developed in the middle of the series. There is an absence of all ossification of any of the tendons of the muscles of the back, so often seen in other groups of birds; while the metapophyses of the broad and well-developed transverse processes are fairly in evidence.

The *neural canal* varies but little in capacity throughout the vertebræ of the cervical and dorsal regions of the spine; and upon the whole, all the parts of these bones are reduced to the simplest form known to occur in the vertebræ of birds.

All the *ribs* are very thin and slender, with the "epipleural appendages" in the mid-series very long. These last are all coössified with their respective ribs in the dorsal ribs, while they are entirely absent in the case of the cervical and pelvic ones. *Costal ribs* are also delicately fashioned, and the last pair of them, in either instance, do not reach the costal border of the sternum, but run, in both cases, into the rib next beyond, to fuse with it at a point some little distance above its sternal articulation.

Coming to the *pelvis,* I find it to possess characters corresponding with those as they occur in the pelves of typical petrels generally. That portion of it recognized as the "sacrum," made up, as it is, of *eleven* vertebræ, is not large at its extremities, while it presents an unusual swell for its middle third. Here the various outstanding processes are very short and inconspicuous, although the leading two of them abut against the nether surface of the ilium upon either side. This also applies to the three "presacral" vertebræ, wherein the diapophyses are short and connected by bone at their outer extremities. The last five sacrals possess much longer diapophyses, and they, too, have their outer terminations fused together by an osseous connecting band, which may or may not be extended to the ultimate vertebra. Upon the outer edge of this band, on either side, the surface is molded to receive in articulation the ilium of that side, as are the transverse processes of all the vertebræ beyond.

The *ossa innominata* do not coösify with the sacrum, and may be

easily detached from it. Along the sides of the latter we are to note that, in the case of the leading seven (7) vertebræ, the exit for the *sacral nerves* consists, in any case, of small, twin foramina, one being placed immediately above the other. We also find this in the Shearwaters and many other birds, both land and water species. The crest of the sacrum of the bone here being considered is well developed and extends from the leading vertebra, backwards, to the middle of the bone, where it is lost upon the general surface. Its superior margin is thickened by the edge being capped by an osseous dilation of nearly a millimeter in width. This projects well beyond the crest anteriorly, overhanging the prezygapophyses of the first sacral vertebra. (Compare the figures of sacra upon Plates XXVI and XXVII.)

Passing to the *ilium* of an "os innominatum," I find the preacetabular part to have an average length of about 2 cms. Its edges are sharp and round; the smooth surfaces of its dorsal and ventral aspects being concave in the first and correspondingly convex in the latter instance. Dorsad, the preacetabular part of the ilium is of limited extent, and the aforesaid concave and convex surfaces are reversed. The rounded *antitrochanter* faces directly downwards and forwards, occupying its usual site. Hardly any osseous base is to be found in the circular cotyloid cavity, and it is divided from the large elliptical ischiadic foramen by a very narrow isthmus of bone. There is no evidence of any *prepubic* process, while the rather small obdurator foramen is almost entirely merged into the "obturator space," which is here very extensive. On its lateral aspect, the *ischium* is quite flat and entirely smooth. Posteriorly it is produced backwards and downwards as a delicate and curved process of considerable length, which finally terminates in a little foot-like expansion that articulates by its entire lower edge with the superior margin of the narrow, slender, and elongate *postpubis* at just a short distance anterior to its free posterior extremity (fig. 63, Pl. XXVI). There is no true "ilio-ischiadic notch" present in this pelvis, as seen in many other birds, for example, in *Puffinus borealis* and other Shearwaters. This "notch" is also to be seen in some of the Fulmars, as *Fulmaris glacialis,* but it is more open than it is in the Shearwaters. (Compare figs. 17, 21, and 25.)

But four or five *caudal vertebræ* were discovered of *Æstrelata vociferans,* and they appear to be from the middle of the series of

those bones of the skeleton of the tail. No *pygostyle* at all occurs among the material, which is somewhat remarkable, for an unusual number of cervical and dorsal vertebræ were found, and the terminal piece of the tail is comparatively large in all petrels. The caudal vertebræ are of simple form in mid-series, with short, rather stout diapophyses that are bent downwards. Neural spines are also present in the majority of them, while apparently the last segment or two possessed a bifurcated hæmal spine. It would appear as though the neural canal extended posteriorly as far as the pygostyle, for it is present in all these caudals in the collection.

In all probability *Æ. vociferans* possessed seven (7) caudal vertebræ and a pygostyle. The tubinarine form possessing the greatest number of these caudal vertebræ is *Pelecanöides urinatrix,* which has nine (9) and a terminal piece. Forbes, in his above-cited table, gives *nine,* but does not count the pygostyle (fig. 21, Pl. XX). This is a mistake, I think, unless it be generally understood that the aforesaid terminal bone is, in a way, to be reckoned as an ossification apart from the vertebral chain as a whole.

The Sternum and Shoulder Girdle.—As will be noted from the lists given above, there are nearly a dozen sterna of the petrel here being examined in the collections at hand, and plenty of scapulæ, coracoids, and os furculæ to study and compare, with the view of noting the characters of that part of the skeleton. (See figures of these several bones on Pls. XXII, XXIII, XXIV, and XXV.)

The *sternum* varies to some extent in some individuals, but probably not for sex. In some the outline of the body is nearly square, while in others it is more, or slightly more, parallelogrammatic. There is also a variance in the widths and lengths of the xiphoidal processes, they being short and narrow in some sterna, and rather wider and longer in others. The bone appears to always be non-pneumatic, and when viewed from above the body presents a great concavity with respect to form. The triangular and pointed costal processes flare out, one upon either side, and there are, as a rule, six narrow facets upon either costal border for articulation with the costal ribs or hæmapophyses. Its anterior border is thickened so as to afford surfaces for articulation with the coracoids; they meet each other anteriorly at an angle of nearly 90 degrees, there being a well-pronounced transverse notch at the apex of the angle in the mid-

longitudinal line. This is separated from the small, flattened "manubrium" beyond it by the rather capacious coracoidal grooves, which latter are continuous at the median point, and carried around laterally, on either side, to the middle of the base of the coracoid process.

Carina has a thickened anterior border, which is longitudinally grooved down its anterior face, below which the "carinal angle" projects with great prominence (fig. 32). This keel, too, is carried the entire length of the sternum to the ultimate point in the middle line of the mid-xiphoidal process. On the whole it is deep and of triangular outline, with slightly thickened free margin below. The convex ventral surface is smooth, all to the usual raised lines found there indicating the divisional areas for the pectoral muscles.

Distally, the xiphoidal margin is twice-notched upon either side, the "notches" being profound and broad, giving rise to a mid-xiphoidal process, with a lateral one and an intermediary one upon either side.

This sternum has an average width of 2.8 cms. by a length of 4.3 cms., the former being taken on a transverse line adjoining the middle points of the costal borders, and the latter from the middle point of the anterior border to the posterior extremity of the keel. It will be observed that this sternum is quite a different appearing bone from that of a typical Shearwater, for example, such a form as we see in figs. 126 and 127 of Plates XXIX and XXX.[15]

On the plates already cited above I give a number of figures of the *furculum,* coracoids, and scapulæ of this extinct bird. The former is seen to be of the usual U-form of bone found in Petrels generally. The clavicular limbs are much bowed to the front, while the hypocleidium may be said to be aborted below. Above its usual site, anteriorly, an excavation appears, while behind it, on the posterior median

[15] Since describing above the skeleton there shown, I have received the following letter in regard to it, dated December 4, 1915, at the Museum of Comparative Zoölogy, Cambridge, Mass., and addressed to myself:

"*Dear Sir:* I duly received the Shearwater skeleton loaned you for study. It came without any injury whatsoever. I asked our Mr. Bangs to compare the skeleton with skins in the collection, and he identifies the skeleton as *Puffinus assimilis* without doubt, and probably the subspecies *gavia.*

Yours truly,

SAMUEL HENSHAW,
Director."

surface, a vertical line is raised where the clavicles are joined below. The free extremities above are drawn out to some extent and pointed. Each has on its external face an antero-posterior elongated facet for articulation with the corresponding coracoid. The apices of the free extremities are 2 cms. apart; and from either apex of a free end to the median lowermost point of the arch equals 3.4 centimeters, more or less.

For its entire length a *scapula* is very much compressed vertically, and about a centimeter or less of its free posterior extremity is markedly dilated. It is uniformly curved in the vertical plane, from one end to the other, while its outer border is gently concave throughout its length, its inner one presenting a similar convexity—either border being rounded off rather than sharp. Distally, the bone is blunt-pointed, while the vertically flattened head, supporting the usual articular facets, presents anteriorly a slightly thickened transverse edge of margin for articulation with the coracoid of the same side. The extreme length of a scapula averages about four centimeters, with a width of three millimeters.[16]

The Pectoral Limb (Plates XXIV–XXVI).—There is an unusually large number of the bones of this extremity in the combined collections before me at this writing—that is, when we come to consider the fact that they represent an extinct species, and the additional fact that our National Museum has not a single skeleton of any Petrel of the genus *Æstrelata*—extinct or existing—in its entire collection of skeletons. Here there are, to represent *Æ. vociferans* alone, nearly 50 humeri, with all the other long bones of the arm in proportion.

It is very interesting to find that the *humerus* of *Æ. vociferans* agrees *very* closely, in all of its characters, with the humerus in any average Shearwater of the genus *Puffinus;* at the same time it departs, in many respects, from the humerus of any of the smaller Petrels of the genus *Oceanodroma* with which I have compared it, and perhaps from the humeri of the allied genera *Bulweria, Halocyptesia,* and *Thalassidroma,* which have not been seen by me. These differences

[16] In examining these scapulæ for the last time, I came across the anterior half of one that evidently belonged to a much smaller bird than *Æstrelata vociferans;* there is a great probability that it may have belonged to a specimen of *Puffinus parvus,* a distinct species described above. It is to be found in the collection belonging to the American Museum of Natural History.

are very marked, but it will hardly be necessary to enter upon the description of them here. I may say, however, that they are principally to be seen in the proximal extremities of the bones in question. As a matter of fact, the small Petrels just named are, with respect to their osteology, very different birds as compared with the representatives of either of the genera *Æstrelata* or *Puffinus*.

In our present subject the humerus has an average length (both sexes considered together) of 8.15 cms., its smooth shaft being but very slightly curved; the convexity is on the anconal side and uniform from head to distal end.

The radial crest is distinctly triangular in outline, the superior angle terminating in a distinct nib, the whole being bent palmad.[17]

The ulnar protuberance or "inferior crest" is very conspicuously developed, and, on the whole, bent toward the anconal side. It harbors, as usual, the pneumatic fossa, which is here deep and circumscribed. At its base may be discovered a few minute pneumatic foramina, for nearly the entire skeleton of this Petrel is very largely permeated by air, the usual "air-holes" being found at their usual sites.

The "incisure capitis" is well marked, while the articular part of the head of the bone is not especially extensive. Points about it for muscular insertion are defined by distinct, localized areas, marked with varying definition in different bones, or rather in those that belonged to different individuals.

Distally, we see the large epicondylar or ectepicondylar process standing out conspicuously from the side of the shaft, roughened, as it is, for tendinal insertion. More centrally, and just above the trochleæ, is a deep, circumscribed concavity for the insertion of the inferior brachial muscle. The entepicondylar process is particularly prominent; and, indeed, this end of the humerus in the skeleton of the bird under consideration has each and all of its characters unusually pronounced, though not any more so than they are found to be in any of our Shearwaters of the genus *Puffinus*.

According to the variations due to age and sex, the length of the *ulna* may run all the way from 8.6 cms., more or less, to 9.4 cms., more or less, and is seen to be a strong and nearly straight bone, being

[17] This crest, the "crista superior" of some authors, is low and rounded in *Oceanodroma*.

but very slightly bowed anconad-wise; its shaft is smooth, and for the most part trihedral upon section. Papillæ for the quill-butts of the secondary feathers of the wing are but faintly in evidence, the first five or six proximal ones being best marked. At the extremities the usual articular facets for the humerus, radius, and ulnare are present, and to all appearances the bone is a pneumatic one.

A *radius* is a very slender and very straight bone; it has an average length of 8.55 cms., and presents the usual ornithic characters found in the Petrels generally at either of its extremities.

No specimens of the two bones of the carpus—the *radiale* and *ulnare*—are found in any of these collections; but it is fair to presume that they agreed in all essential particulars with the corresponding elements in the wrists of typical Petrels generally.

As in the case of the long bones of the brachium and antibrachium, the main bone of manus—the *carpometacarpus*—is found to vary in length, and for similar reasons. Upon measuring a series of them, they seem to stand between 4.2 and 4.35 centimeters in this respect (Pl. XXVI, figs. 65, 66). The main shaft is straight and subcylindrical in form, being longitudinally grooved down its palmar aspect for tendinal passage, which groove is best marked distally. Shaft of medius metacarpal is almost parallel to the last described, but only about one-fifth its caliber. It is transversely compressed for its entire length, and gradually enlarges as it coössifies with the distal extremity of index metacarpal. This bone likewise has all the appearance of being a pneumatic one; but I have failed to discover, with absolute certainty, the foramina to substantiate it. They are probably very minute and at the proximal extremity.

On Plate XXVI (figs. 71, 72) I give two views of the proximal phalanx of index digit, which shows its narrow expanded portion, ending distally in a distinct, outstanding little process, with another nearly as prominent at the opposite side of the distal articulation. This expanded part has a very thin, sharp edge or margin posteriorly, while the anterior surface of its shaft is flat.

Several terminal digital phalanges occur in these collections, and I have also figured them on Plate XXVI (figs. 75, 80–82). They present, with their trihedral shafts, pointed distal extremities, and proximal articular ends, nothing worthy of detailed description; though, doubtless, were one to compare a sufficient series of these bones with

a corresponding series chosen from Shearwaters and other tubinarine birds, one could tabulate the exact difference to be found among them. They would be unimportant in value, however, as compared with bones of other parts of the skeleton presenting more distinctive characters, for example, such as we find in the skull, the sternum, and some of the long bones of the limbs. These remarks apply equally well to the numerous phalangeal joints of the pes.

The Pelvic Limb (Plate XXVIII).—For the most part, the bones of this extremity seem to enjoy more or less pneumaticity, especially the shafts of those of the thigh and leg. We are struck with the small size and *shortness* of the *femur* as compared with the humerus of the pelvic limb. It averages but little over three centimeters in length, its subcylindrical shaft being but slightly bent between its extremities, the convexity being in front, and best marked at about the juncture of middle and lower thirds.

The "trochanter major" is but feebly developed, and the summit of the bone is flat and articular, the small *caput femoris* being profoundly pitted for the insertion of the ligamentum teres. Distally, the condyles are also small, and present all the usual characters as we find them in the femora of Petrels generally. In Shearwaters the shaft of the femur generally is far more bent or arched than it is in *Æstrelata* and its immediate congeners. In *Oceanodroma* the shaft of this bone is very straight.

No *patellæ* occur in any of these collections, and so small as sesamoid was probably overlooked in collecting.

Passing to the bones of the leg, I find that the *tibiotarsus* varies in length as in the case of the other long bones of the limbs. It averages between 6. and 6.3 centimeters in length (Pl. XXVIII, figs. 122, 123). It has a very straight shaft, which, for its middle third, is subcylindrical in form, and somewhat compressed antero-posteriorly below.

Proximally, the bone is characterized by a very conspicuous cnemial process, to which I have referred on a former page of this work. This process is flat and triangular posteriorly; its ectocnemial part is considerably reduced, while the entocnemial portion is expanded and extends directly to the front. The common superior border to these two processes is somewhat thickened and of a sub-hemicircular outline. As already shown above, this is the general character of the

cnemial process in the true Petrels, while in the Shearwaters (*Puffinus*) its summit is more generously and characteristically extended, constituting a certain *facies* that is unmistakable.

At the distal end of this tibiotarsus of *Æstrelata vociferans* we note the deep, longitudinal groove for tendons anteriorly, spanned below by the minute osseous bridge to confine them within it. The condyles are prominent here owing to the deep intercondylar valley between them. Posteriorly they are sharp-edged, and the space between them is much shallower. Externally, we note the thin, fibular ridge for articulation with the *fibula,* which latter is but a feebly developed bone, lightly attached to its larger companion by a scanty ligamentous attachment. The lower free end of the articulated fibula reaches down to about the junction of middle and lower thirds of tibia's shaft,[18] and it is here reduced to almost hair-like dimensions.

Petrels, as a rule, have a slenderer *tarsometatarsus* for its length than have the Shearwaters and some other *Tubinares* (compare figs. 106–110, Pl. XXVIII; also figs. 20 and 24); while at the same time its characters are pretty much the same. In a series of the bones its length runs 3.4 cms., 3.5 cms., and so on, which is about the average for them. At the summit we find the twin articular concavities for the femur well marked, and a well-developed intercondylar eminence between them on the anterior border. The *hypotarsus* is rather short except upon the inner side, where it is continued down its upper third of the shaft as a thin, lateral plate of bone. For the rest it is composed of three processes, 3.7 mm. deep, dividing it into two deep grooves for the passage of the usual tendons of the muscles of the leg.

The shaft is straight and strongly grooved, both anteriorly and posteriorly, for its entire length, longitudinally. Passing to the *distal trochleæ,* it is to be noted that the central one is considerably bigger than either of the others, while it is also placed lower down and more to the front. The inner one is the highest up and situated the farthest to the rear, while the outer one holds an intermediary position. Between these three trochleæ, grooves are carried up a short distance

[18] As slender as the attachment of the fibula to the tibiotarsus is, I find one specimen in which the two bones did not part company, notwithstanding the long time which must have elapsed since the death of the bird to which they belonged; the circumstances under which the specimen was collected and the transportation and handling since.

upon the anterior aspect of the shaft, especially between the middle and outer ones, wherein we find, as usual, and at its usual site, the elliptical foramen for the passage of the anterior tibial artery to the plantar aspect of the foot.

There is rather a large number of *pedal phalanges* in the collection, especially in Mr. McGall's part of it. These I have assorted according to their *lengths,* but without a skeleton of the foot of this Petrel before me, or of an *Æstrelata* of any species. In face of the fact that these joints vary in size according to age and sex, and, further, that there are nearly thirty of them in the two feet of a single individual, I would hardly undertake to restore a foot—either the left or the right—from the material at hand. Were *all* the phalanges represented, and for *both* feet, this could be done with certainty, however large a number there was in the collection. An X-ray or radiograph of a foot of one of the specimens of *Æstrelata caribbæa,* of the U. S. National Museum collection, might be of assistance in the matter, but the gain would hardly justify the outlay in time and expense. In any event, the skeleton of *pes* in *Æstrelata vociferans* was doubtless quite in agreement with what we would find in any medium-sized Petrel now in existence, and our knowledge of that is already in the possession of science.[19]

ADDENDA.

After the above memoir was entirely ready for publication, with its sixteen plates, Mr. McGall made additional collections of bird-bones at the Bermuda caves, visiting others not previously examined

[19] Among the *pedal phalanges* of Mr. McGall's collection, I have met with a single joint which I am inclined to believe belonged to the species of Shearwater now bearing his name and described above. It is very straight and markedly slender; further, it is altogether too long to have belonged to *Æstrelata vociferans,* as it measures no less than 2.9 cms. in length. In the skeleton of the foot of a specimen of *Puffinus borealis* (No. 17769, Coll. U. S. Nat. Mus.), the *basal phalanx* of the *inner toe* measures in length 3 cms., and the bone is slenderer than the basal joint of the middle toe, which latter measures in length 2.8 cms. At the same time it is, as I say, a somewhat stouter bone than the aforesaid basal phalanx of the inner toe. Judging from this data, I believe that the subfossil pedal phalanx just referred to above belonged to an adult specimen of *Puffinus mcgalli,* and possibly to the same individual to which belonged the sternum described upon a previous page of this memoir.

by him. In these extremely dangerous operations he was associated with Mr. Anthony Tall, though the former explorer was the one who undertook the more hazardous descents necessary to reach the cave entrances, which, in any instance, invariably faced seawards; so that a person, in order to gain entrance, had to be lowered down by a rope and receive other assistance at the hands of his friends above.

The material thus collected was sent to the American Museum of Natural History, and some of it was distributed among other American and British museums. Originally it was the intention to have the American Museum publish this memoir with its addenda when completed by me; but, after holding it for many months, so much previously accepted matter preceded it for publication that Mr. McGall and his associates decided to allow me to place it where it would sooner see the light and the results be given to science. This was not fully decided upon until both of the explorers had visited me at my home in Washington, D. C., and fully discussed the subject, later giving me instructions in writing in regard to my choice of place for publication.

After this had all been duly arranged, Doctor Lucas kindly turned over to me the added collection of bones that was in his keeping, and it was found to consist of the following lots. This all occurred during the summer of 1917. In the spring of that year, when this country declared war against Germany, Mr. McGall was commissioned first lieutenant in the United States Coast Artillery, and at this writing (Dec. 30, 1917) he is probably with our troops in France.

This extensive material has all been carefully compared with the bones described in the main memoir, and the results, in the way of numbers of specimens and their identification, are set forth in the following:

TABLE.

17 crania of *Æstrelata vociferans*. More or less imperfect; show but little individual variation. On the frontal region (superiorly) the transverse diameter between inner edges of supraorbital glandular depressions varies in length from one to three millimeters. Some little variation in size.

1 perfect mandible of *Æ. vociferans* and 8 pieces of others.

9 ossa quadrata of *Æ. vociferans*.

1 pterygoid.
150 vertebræ (not assorted and not referred); probably belonged largely to *Æ. vociferans.*
200 ribs (approx.). (Not assorted or referred.)
32 sterna (adults), more or less imperfect, of *Æ. vociferans.*
49½ coracoids of *Æ. vociferans.* (Thirty lefts, nineteen and a half rights.) Adults more or less perfect.
36 scapulæ; 23 rights, 13 lefts. Mostly perfect.
22 perfect furculæ of *Æ. vociferans.*
9 fragments of furculæ of *Æ. vociferans.*
31 ossa innominata, right side; majority perfect. *Æ. vociferans.*
24 ossa innominata, left side. *Æ. vociferans.*
39 sacrums of *Æ. vociferans;* large number nearly perfect.
36 humeri (right side) of *Æ. vociferans.* Nearly all perfect, and adult, with but one or two exceptions.
49 humeri (left side) of *Æ. vociferans.* Mostly perfect; three are but halves; three subadult.
41½ left ulnæ of *Æ. vociferans.* All more or less perfect. Adult.
51 right ulnæ of *Æ. vociferans.* All more or less perfect. Adult.
90 radii of *Æ. vociferans.* Nearly all perfect. Rights and lefts mixed. No carpal bones found.
21 carpometacarpi; adults; nearly all perfect. *Æ. vociferans;* rights.
26 ditto; left side. Proximal joints of index digit; *Æ. vociferans.* 13 of right side, or right pectoral limb; 11 of left side, or left pectoral limb.
29 non-assorted finger-joints. Apparently most all of them belonged to *Æ. vociferans.* Adults.
13 femora (rights). *Æ. vociferans.* Quite perfect. Adults.
23 femora (lefts). *Æ. vociferans.* Quite perfect. Adults.
12 fibulæ; adult. *Æ. vociferans.*
41 tibio tarsi (rights). *Æ. vociferans.* Nearly perfect, many quite so. Adults.
38 tibio tarsi (lefts). *Æ. vociferans.* Nearly perfect, many quite so. One has a perfect fibula articulated with it.
13 tarso-metatarsi (rights). *Æ. vociferans.* Quite perfect. Adult.
22 tarso-metatarsi (lefts). *Æ. vociferans.* Quite perfect. Adult.

68 toe-joints (adults), mostly quite perfect; belonging to different species in the collection. Not assorted or referred.

MISCELLANEOUS LOTS.

I was personally informed by Mr. Edward McGall and Mr. Anthony Tall that in other lots of the collections sent to Harvard College, British Museum, etc., were found specimens of an os furcula of a bird of very small size. This report is sustained by the present collection, for in one or two of the miscellaneous lots I find various bones that belonged to some very small species; in fact, as small as any bird in our present American avifauna, barring the humming birds. These bones are as follows:

In one lot:

Left femur (distal condyle gone).

Right tarso-metatarsus, distal moiety (adult) measures 1.5 mm. across the ends of the trochleæ.

Left femur, distal moiety. Transverse diameter of condyles 2 mm.

Shaft of a tibio-tarsus, extremities missing.

In another lot of:

Numerous bones of birds described in the memoir occur also the distal moiety of a femur that belonged to a very small species of bird; also a perfect left femur (same species ?), which measures 1.6 cms. in length; a rib; the distal portion of a left tarso-metatarsus, and a nearly perfect left humerus; length 1.5 cms. The bones in this lot were mixed up in a considerable quantity of fine, dry silt from the bottom of the cave. Some minute species of mollusks (2 sp.), with a form like a helix, were also found in this lot.

In still another lot:

Made up of various calcined bones of species described in the memoir (fragmentary), there occurs a nearly perfect right tibio-tarsus of a bird, with a total length of 3.1 cms. Apparently the bone is of a passerine type and belonged to a species about the size of a large sparrow.

After all the bones enumerated above had been carefully selected

and duly counted, there remained quite an extensive collection of bones which, upon comparison with the corresponding ones in the collection as a whole—that is, with all the material that ever came before me from the Bermuda caves, both main lots—proved to be, beyond all doubt, those of *Puffinus parvus*. These bones further agree, in their morphology, lengths, and general proportions, with the *type bones* of this extinct Shearwater, as figured and described in the body of the present memoir. In this lot there are found:

4 skulls (adults), pterygoids and quadrates missing; the basal, frailer parts broken off and lost. (No mandibles accompany them.) Otherwise quite perfect.

(In the large collection of *vertebræ* listed above there may be, and probably are, some that belonged to this small Shearwater. This applies to other small bones, as toe-joints, finger-joints, etc.)

5 sternums; more or less perfect.
4 coracoids; 1 right and 3 lefts.
5 scapulæ; 2 rights and 3 lefts.
2 os furculæ (perfect); 4 fragments of others.
13 humeri; 4 rights, 9 lefts.
10 radii (rights and lefts); some quite perfect.
9 ulnæ; three rights and 6 lefts.
6 carpo-metacarpi; 2 rights, 4 lefts.
4 femora; 1 right, 3 lefts.
9 tibio-tarsi; 3 rights, 6 lefts. All quite perfect; in fact, all the limb-bones are in an excellent state of preservation, and the majority of them perfect.
7 tarso-metatarsi; 5 rights, 2 lefts.

Finally, the collection contains the imperfect sternum of a very small species of Shearwater (*Puffinus*), smaller than Audubon's Shearwater. It is more than likely that this bone belonged to an adult specimen of *Puffinus parvus* Shuf. The antero-superior portion is broken off and lost; otherwise the bone is quite perfect.

CONCLUSIONS.

There is but little to be said under this head. The creation of the new species, *Puffinus mcgalli* and *P. parvus*, is amply justified, based,

as it is, on good and sufficient material in either case. With respect to *Æstrelata vociferans,* I am free to confess that when this work was in its early stages I was by no means convinced that a good case was to be made out, especially when all the reports came in to me from so many large museums in America and Europe that there were *no skeletons* of any species of *Æstrelata* in existence; or, if there were, they could not pass out of the keeping of the institutions owning them for the use of a private investigator engaged upon such researches as are here set forth. However, as soon as a serious study of the material was entered upon, it became evident that the subfossil bird-bones of the "Cahow" of Bermuda belonged, without question, to a Petrel and not to a Shearwater, as has heretofore been generally supposed. It then remained but to prove to which species they belonged; and, as the steps leading to this proof are very fully demonstrated, point after point, in the present contribution, it is obviously unnecessary to recapitulate them here.

Note.—The collections made by Mr. Edward McGall and Mr. Anthony Tall, listed on pp. 382 *et seq.,* which were presented by these gentlemen to Dr. R. W. Shufeldt, have been turned over by Dr. Shufeldt to the Carnegie Museum, and have become its permanent property.

W. J. HOLLAND.

EXPLANATION OF PLATES.

(All the figures in the plates are reproductions of photographs made by the author of the specimens described.)

PLATE XVI.

FIG. 1. Superior view of the skull of the "Cahow." McGall Coll., nat. size; adult; imperfect (right zygoma lost, etc.). Some of the matrix still seen adhering to it, between the orbits and in the nostrils. Lower mandible removed. Either *lacrymal* coössified at the side of the skull and the suture obliterated.

FIG. 2. Same view of the skull of another individual of the same species as shown in Fig. 1; nat. size; adult. McGall Coll. Imperfect. Mandible removed.

FIG. 3. Same view of the skull of still another individual of the same species ("Cahow") as shown in Figs. 1 and 2; nat. size; adult. McGall Coll. Imperfect. Mandible removed. The three crania shown in Figs. 1–3 show how little individual variation exists, as a rule, in this part of the skeleton of the "Cahow." The shortest line between the supraorbital glandular depressions is, however, seen to vary to some extent.

FIG. 4. Basal view of the cranium of a "Cahow," nat. size; adult. McGall Coll. Mandible removed, and the pterygoids and quadrates missing. Vomer coössified with palatines.

FIG. 5. Right lateral view of the skull of a "Cahow," with *mandible*—the latter doubtless from a different individual. Nat. size; adult. Coll. Amer. Mus. of Nat. Hist. Quadrates were probably from another specimen, while the pterygoids are missing.

FIG. 6. Right lateral view of the skull and mandible belonging to a skeleton in the collection of the U. S. National Museum labeled "*Puffinus obscurus*" (No. 17724, Bermudas, C. Maller, collector).

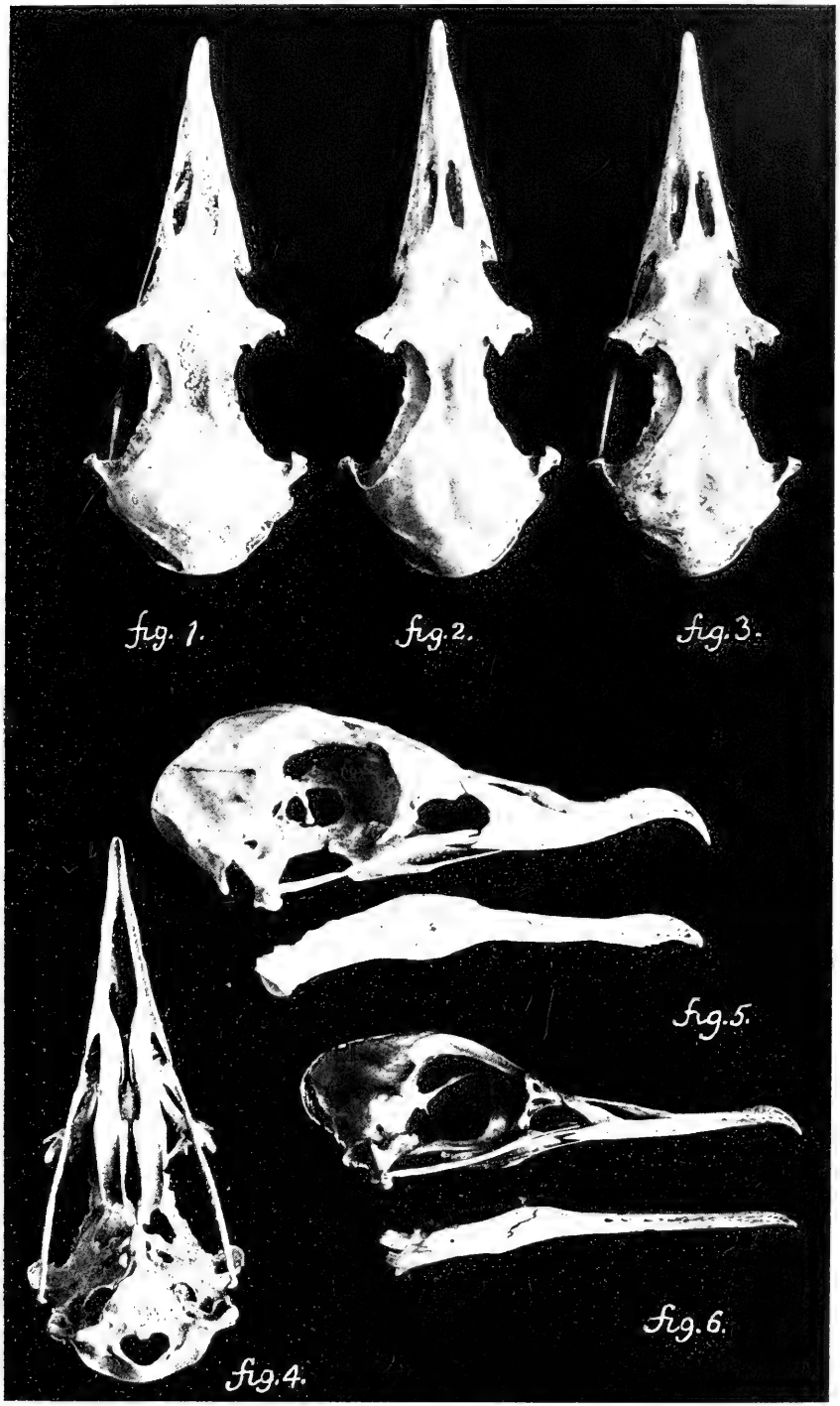


fig. 1.
fig. 2.
fig. 3.
fig. 5.
fig. 6.
fig. 4.

PLATE XVII.

FIG. 7. Right lateral view of the skull, including mandible, of a specimen of *Puffinus major;* adult; nat. size. Mandible detached. (No. 17799, Coll. U. S. Nat. Mus. "La Havre Banks, U. S. F. Comm. Schr. 'Grampus.'")

FIG. 8 Right lateral view of the skull, including mandible, of a specimen of *Puffinus borealis;* adult; nat. size. (No. 17769, Coll. U. S. Nat. Mus., Massachusetts, U. S. Fish Comm.) Mandible articulated and held *in situ* by its dried ligaments.

FIG. 9. Right lateral view of the skull and detached mandible of a specimen of *Puffinus creatopus;* adult. (Coll. U. S. Nat. Mus., No. 18773.)

FIG. 10. Right lateral view of the cranium of an adult specimen lacking the mandible, of *Æstrelata lessoni.* (Coll. U. S. Nat. Mus. No. 14494, Kerguelen Island. Dr. Jerome H. Kidder, U. S. N., collector.) Quadrates and pterygoids missing; margin of lacrymal shaved off, otherwise quite perfect.

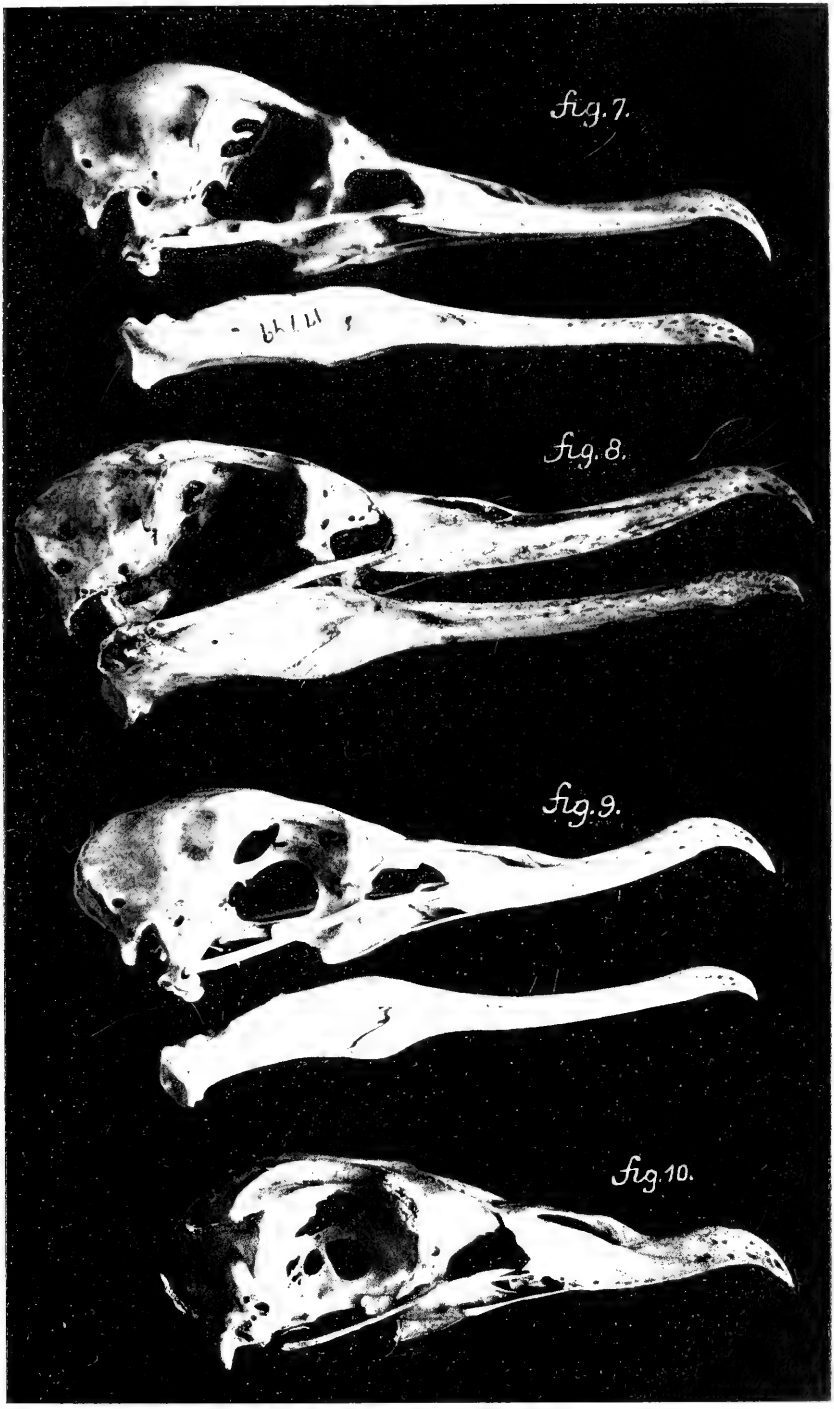


fig. 7.
fig. 8.
fig. 9.
fig. 10.

PLATE XVIII.

FIG. 11. Right lateral view of the skull and detached mandible of an adult specimen of *Daption capense;* nat. size. Coll. U. S. Nat. Mus. No. 18210 (*"Daptium capense"*).

FIG. 12. Superior view of the skull of *Æstrelata lessoni;* same specimen as shown in fig. 10, Pl. II; nat. size; mandible missing.

FIG. 13. Direct ventral view of the sternum *Daption capense.* Belonged to the same individual which furnished the skull shown in fig. 11 of this plate. Nat. size.

FIG. 14. Direct superior view of the cranium of *Puffinus major;* nat. size; mandible removed. Same skull as shown on Plate II, fig. 7.

FIG. 15. Direct basal view of the cranium of *Puffinus creatopus;* mandible removed; quadrates, pterygoids and left lacrymal missing. Same specimen as shown on Plate II, fig. 9; nat. size.

FIG. 16. Superior view of the cranium belonging to a skeleton in the collection of the U. S. Nat. Mus., labeled *"Puffinus obscurus";* nat. size; mandible removed. Same specimen as is shown in Plate I, fig. 6.

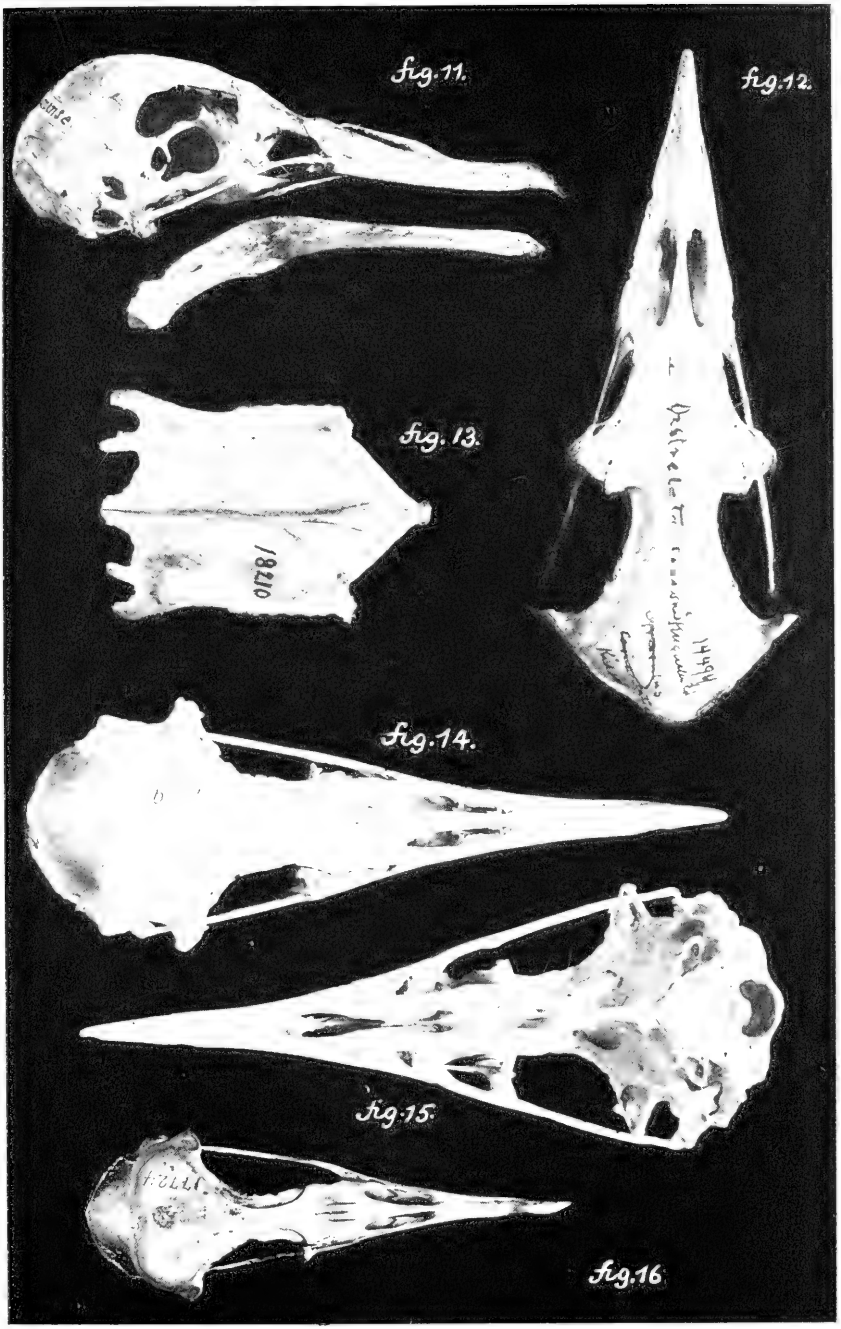


fig.11.
fig.12.
fig.13.
fig.14.
fig.15.
fig.16.

PLATE XIX.

FIG. 17. Direct left lateral view of the skeleton of a specimen of *Procellaria cooki;* adult; nat. size. Coll. U. S. Nat. Mus., No. 18285. ("Great Barrier Island.") Hyoid bones, with right pectoral and pelvic limbs detached.

FIG. 18. Bones of the lingual apparatus (hyoid bones) belonging to the skeleton shown in fig. 17 of this plate; nat. size; viewed from above (dorsal aspect). Glosso-hyal slightly detached.

FIG. 19. Anconal aspect of the skeleton of the right pectoral limb of the skeleton of *Procellaria cooki* shown in fig. 17 of this Plate. Nat. size, and bones normally articulated.

FIG. 20. Mesial aspect of the skeleton of the right pelvic limb of *Procellaria cooki;* nat. size, with the bones normally articulated. Belongs to the skeleton shown in fig. 17 of this plate.

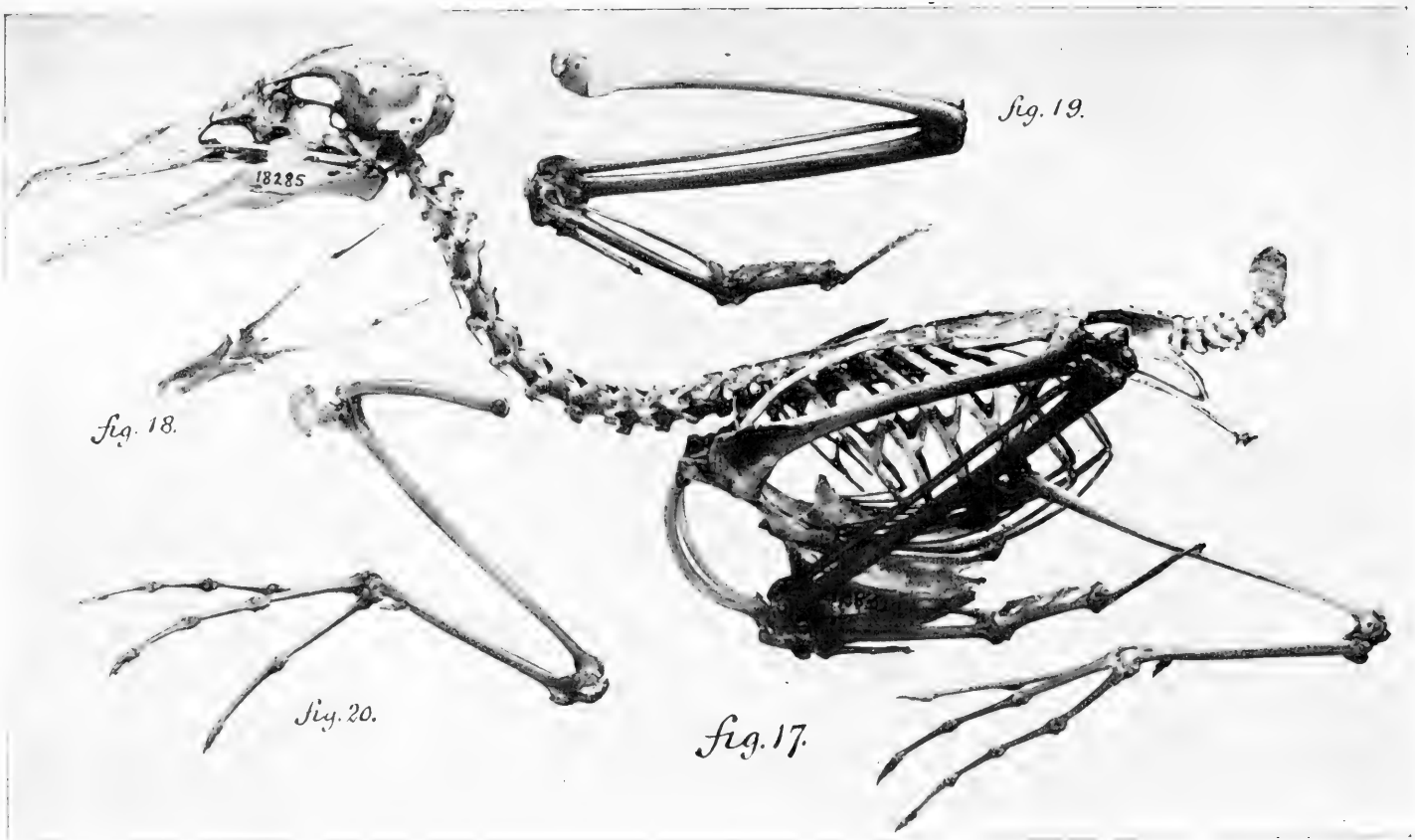


Fig. 19.

Fig. 18.

Fig. 20.

Fig. 17.

PLATE XX.

FIG. 21. Left lateral view of the skeleton of a specimen of the "Diving Petrel" (*Pelecanöides urinatrix*). Adult; nat. size. Coll. U. S. Nat. Mus., No. 18771. Taken in New Zealand waters by Mr. C. F. Adams. Right pectoral and pelvic limbs detached; also the hyoid arches. Trunk skeleton partially rotated, admitting of a view of the anterior of the pelvic basin. Nat. size.

FIG. 22. Bones of the *hyoid arches* seen upon dorsal aspect. Belong to the skeleton shown in fig. 21 of this plate. Nat. size, and normally articulated.

FIG. 23. Skeleton of the right *pectoral limb* of the same specimen shown in fig. 21. Ventral view; nat. size.

FIG. 24. Skeleton of the right *pelvic limb* of the same specimen shown in fig. 21; mesial aspect; nat. size, and normally articulated.

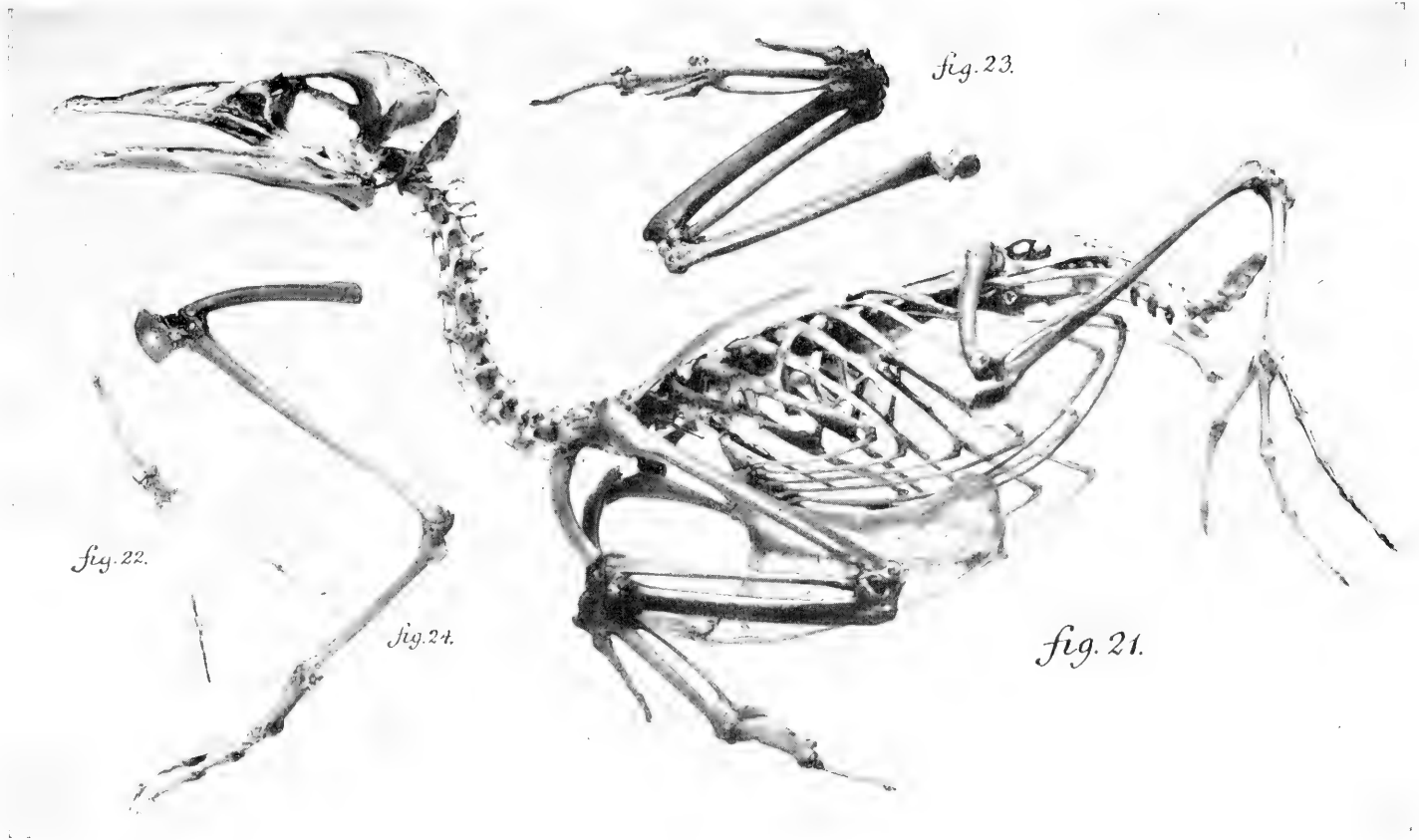


fig. 23.

fig. 22.

fig. 24.

fig. 21.

PLATE XXI.

FIG. 25. Right lateral view of the trunk skeleton of a specimen of *Puffinus borealis;* adult; nat. size. No. 17769, Coll. U. S. Nat. Mus. (Massachusetts, U. S. Fish Comm.).

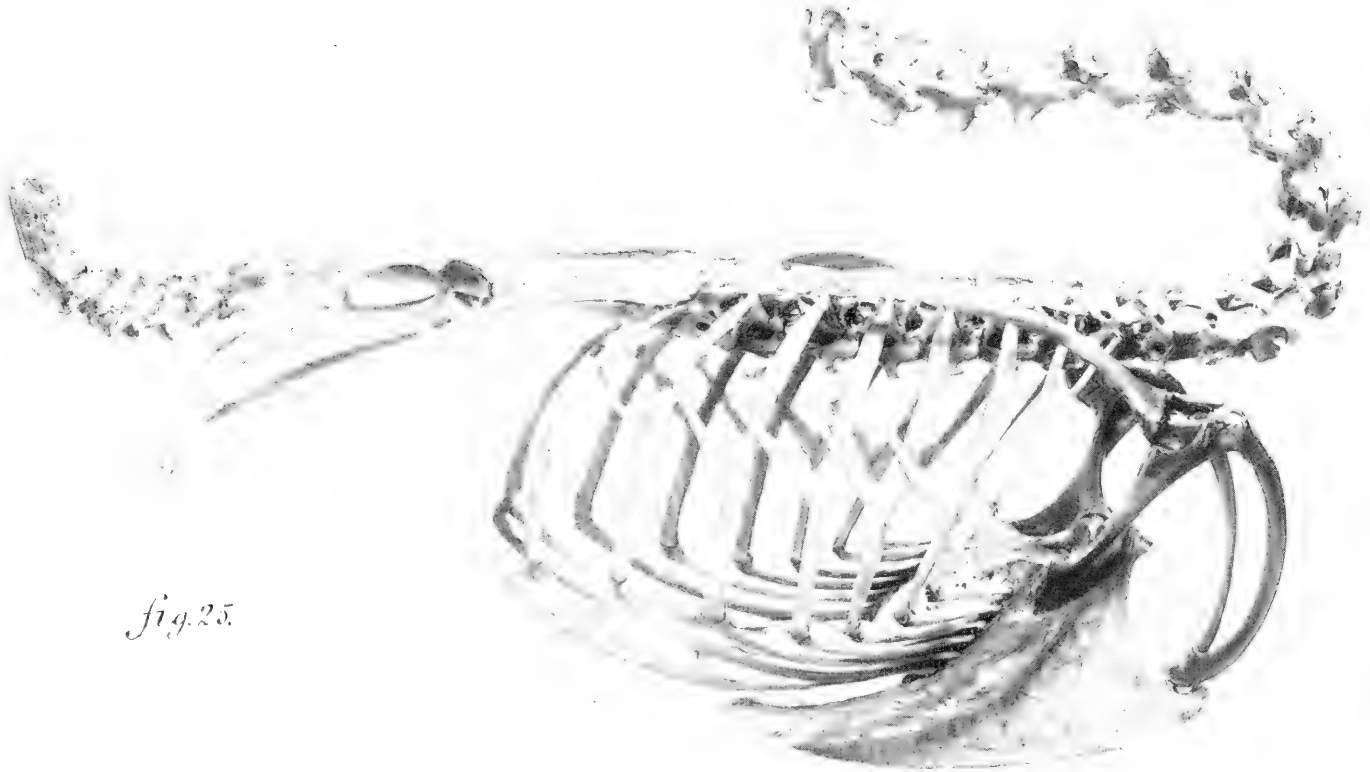


fig. 25.

PLATE XXII.

FIG. 26. Ventral aspect of the sternum of a specimen of a "Cahow"; adult; nat. size. McGall colleition.

FIG. 27. Ventral aspect of the sternum of another specimen of the "Cahow"; adult; nat. size. Collection of Mr. Edward McGall.

FIG. 28. Ventral aspect of the sternum of a specimen of the skeleton in the U. S. Nat. Mus., Division of Birds, labeled: "*Puffinus obscurus*" (No. 17724). Same individual as the one in which the skull is figured on Plate I., Fig. 6. There is a pathological condition present on the left side of the body of this sternum, next to the keel. It was healed at the time the bird was taken, and was either due to disease or a punctured wound. Nat. size.

FIG. 29. Direct ventral view of a sternum of *Puffinus mcgalli* in the McGall collection (Subfossil, Bermuda). Nat. size, and from an adult bird. (See description in the text.)

FIG. 30. Direct ventral view of the sternum of *Daption capense*. No. 18210, Coll. U. S. Nat. Mus.; nat. size.

FIG. 31. Ventral view of the sternum of a specimen of *Puffinus gavia* (No. 18286, Coll. U. S. Nat. Mus. "*Puffinus gavius*," Barrier Island, F. F. Cheeseman, Auckland Museum).

FIG. 32. Right lateral view of the sternum of a specimen of the "Cahow"; nat. size. McGall collection.

FIG. 33. Ventral view of the sternum of a specimen of "*Puffinus obscurus*"; collection of C. J. Maynard. Bones of pectoral arch articulated *in situ*; adult; nat. size. Some of the costal ribs still attached. See description in text.

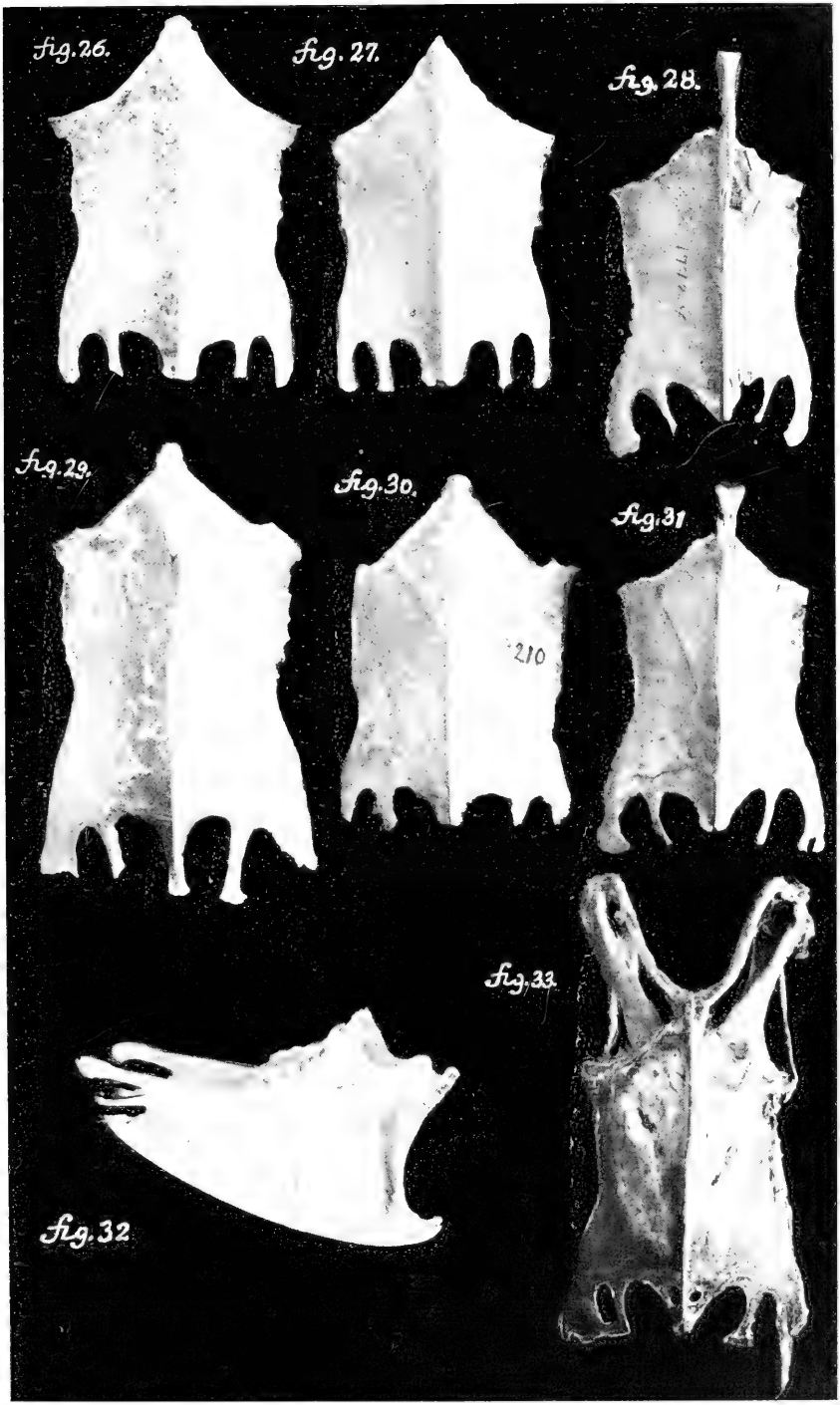


Fig. 26.
Fig. 27.
Fig. 28.
Fig. 29.
Fig. 30.
Fig. 31
210
Fig. 33.
Fig. 32

PLATE XXIII.

FIG. 34. Left lateral view of the sternum of "*Puffinus obscurus,*" with shoulder-girdle articulated *in situ;* nat. size; adult. (See fig. 33, Pl. VII.) From the collection of C. J. Maynard.

FIG. 35. Right lateral view of the sternum of the bird's skeleton, labeled "*Puffinus obscurus*" in the collection of the U. S. Nat. Museum (No. 17724); adult; nat. size. See fig. 28 of Plate VII. (The hole in the keel was made in that a label might be attached to the bone—a procedure not to be recommended.)

FIG. 36. Direct left lateral view of a sternum of *Puffinus mcgalli* in the McGall collection (Subfossil, Bermuda cave). Nat. size; adult. (See fig. 29, Pl. VII, and the description in the text.)

FIG. 37. Left lateral view of the sternum of an adult specimen of *Daption capense* (No. 18210, Coll. U. S. Nat. Mus.). Nat. size. (See fig. 30 of Plate VII.)

FIG. 38. Ventral view of the sternum of a specimen of *Puffinus major;* adult; nat. size. No. 17799, Coll. U. S. Nat. Mus. La Havre Bank, U. S. F. C. Schr. "Grampus." Compare with the sternum next to it on this plate (fig. 39), which also belonged to a specimen of *Puffinus major.*

FIG. 39. Direct ventral view of the sternum of a specimen of *Puffinus major;* adult; nat. size. No. 18076, Coll. U. S. Nat. Museum (Off Cape Race, N. F. "Grampus.") Compare with fig. 38 of this plate.

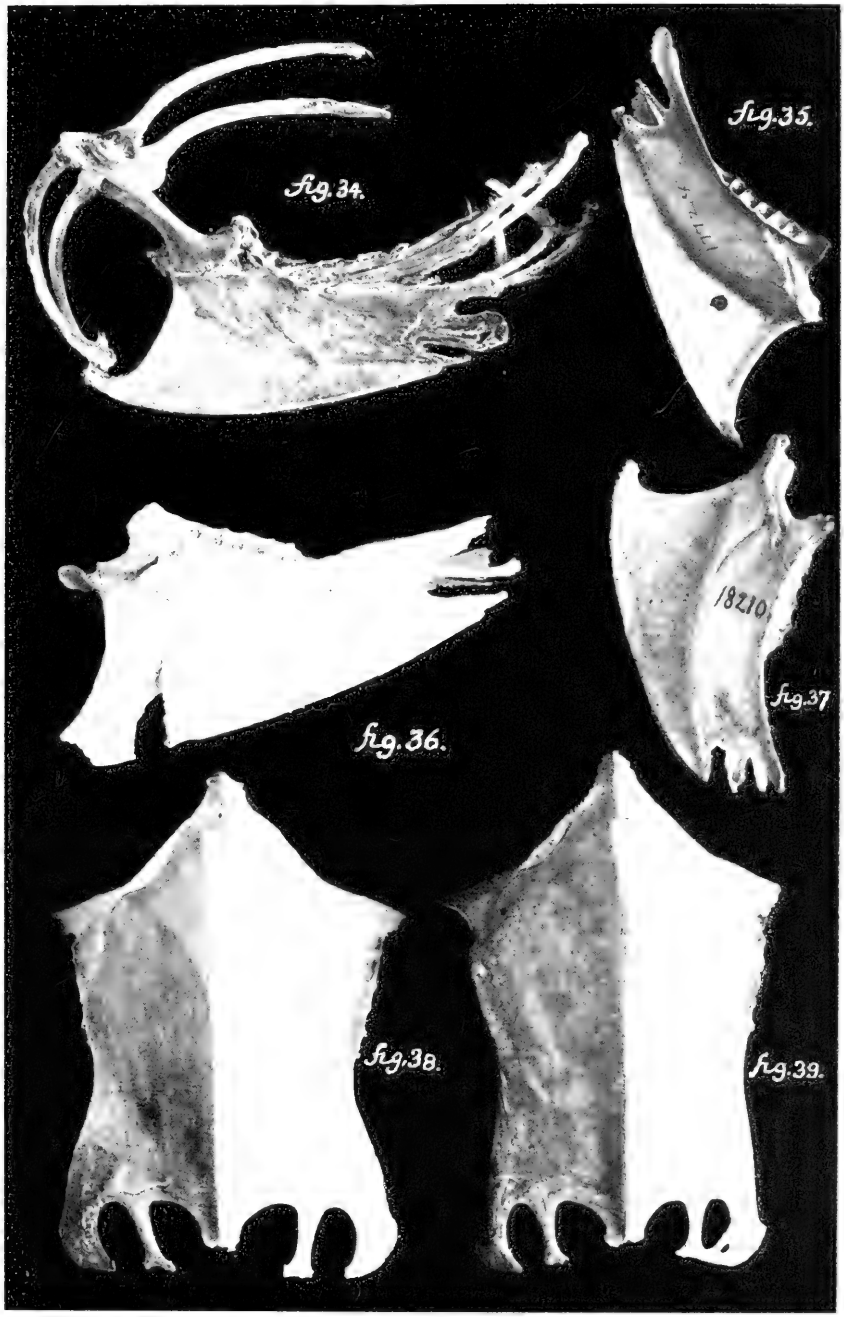


fig.35.
fig.34.
18210.
fig.37
fig.36.
fig.38.
fig.39.

PLATE XXIV.

FIG. 40. Anconal aspect of the right humerus of a specimen of *Puffinus major;* adult; nat. size. (No. 17799, Col. U. S. Nat. Mus.) La Havre Bank, U. S. F. C. Schr. "Grampus."

FIG. 41. Anconal aspect of the right humerus of a specimen of *Puffinus creatopus;* adult; nat. size. No. 18773, Coll. U. S. Nat. Mus. (See fig. 42.)

FIG. 42. Palmar aspect of the left humerus of *Puffinus creatopus.* From same skeleton that furnished the bone shown in fig. 41 of this plate.

FIG. 43. Right ulna of *Puffinus parvus,* subanconal aspect; nat. size. McGall Coll.

FIG. 44. Left ulna of *Puffinus parvus;* inner surface; nat. size. McGall Coll.

FIG. 45. Left radius of *Puffinus parvus;* dorsal surface. McGall collection.

FIG. 46. Left ulna of *Puffinus lherminieri* (*"P. obscurus"*). No. 17724, Coll. U. S. Nat. Mus.; nat. size; palmar aspect.

FIG. 47. Right radius of *Puffinus lherminieri* (*"P. obscurus"*). No. 17724, Coll. U. S. Nat. Mus.; nat. size; dorsal aspect.

FIG. 48. Right ulna (nat. size) *Æstrelata vociferans;* subanconal aspect.

FIG. 49. Right ulna, natural size, *Æstrelata vociferans;* subanconal aspect.

FIG. 50. Right ulna (nat. size) *Æstrelata vociferans;* palmar aspect.

FIGS. 48–50 are all from the collection of the American Museum of Natural History, and show very well the variation in the matter of size of the ulna in this species—a variation due to sex or age and in some instances to both.

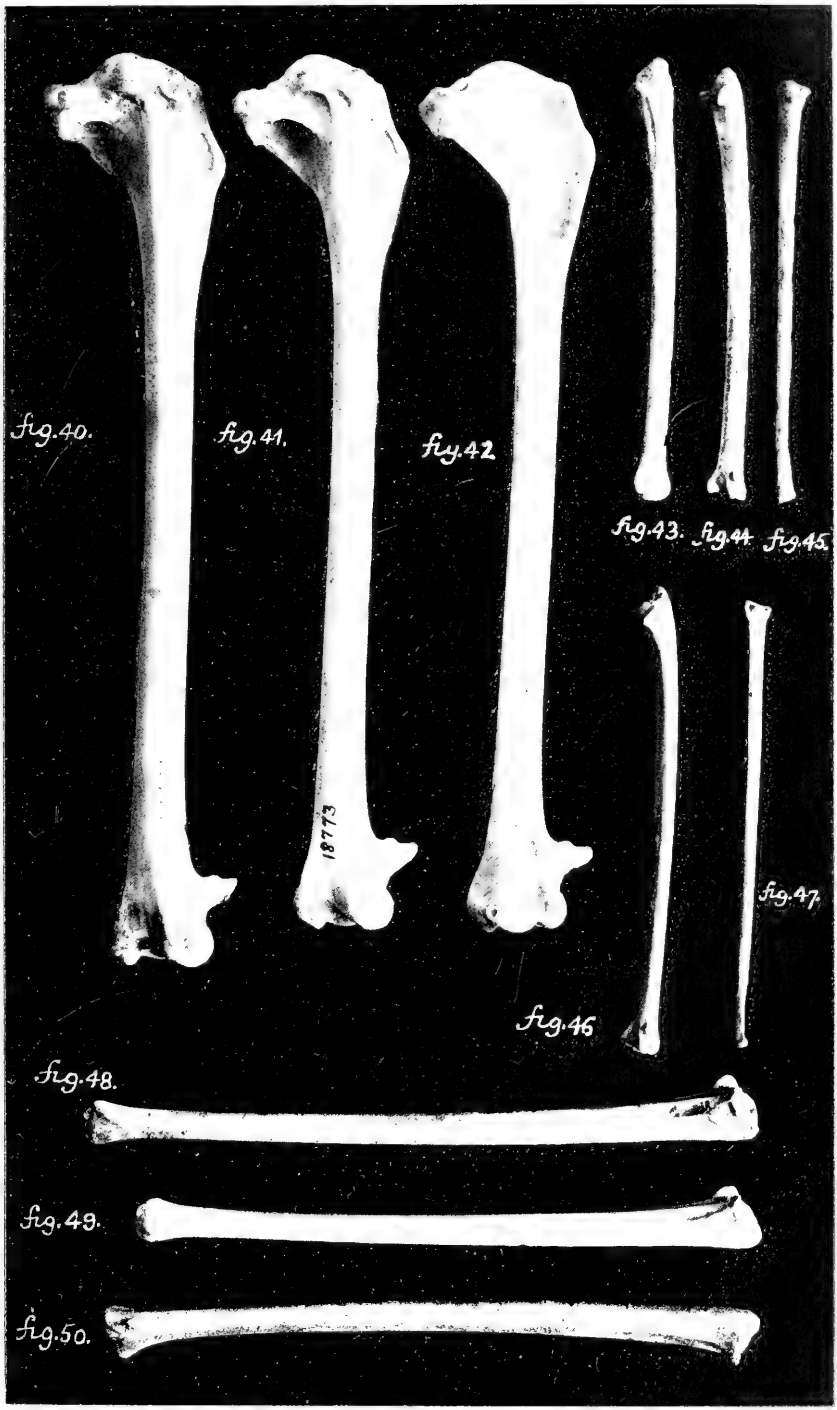


fig.40.
fig.41.
fig.42
fig.43.
fig.44
fig.45.
18773
fig.47.
fig.46
fig.48.
fig.49.
fig.50.

PLATE XXV.

FIG. 51. Right humerus of *Puffinus gavius;* nat. size; palmar aspect. No. 18286, Coll. U. S. Nat. Mus. From the Auckland Museum. F. F. Cheeseman, collector, on Barrier Island.

FIG. 52. Left humerus of *Puffinus gavius,* nat. size; anconal aspect. No. 18286, Coll. U. S. Nat. Mus. (See fig. 51 of this plate.)

FIG. 53. Right humerus of *Puffinus lherminieri* ("*P. obscurus,*" No. 17724, Coll. U. S. Nat. Mus.); nat. size; palmar aspect. C. Maller, collector, Bermudas.

FIG. 54. Left humerus of *Puffinus lherminieri* ("*P. obscurus,*" No. 17724, Coll. U. S. Nat. Mus.); nat. size; anconal aspect. See previous figure.

FIG. 55. Right humerus of *Puffinus parvus,* sp. nov. (extinct). McGall collection. Bermuda Islands. Nat. size; palmar aspect. Subfossil.

FIG. 56. Left humerus of *Puffinus parvus,* sp. nov. (extinct). McGall collection. Bermuda Islands. Nat. size; anconal aspect. Subfossil. May or may not have belonged to the same individual which furnished the humerus shown in Fig. 55.

FIGS. 57–60. Humeri of the "Cahow" of the Bermudas, *Æstrelata vociferans,* sp. nov. (extinct). Collection of the American Museum of Natural History. All natural size. Figs. 57 and 58 palmar aspects; figs. 59 and 60 anconal aspects. These bones show very well the variations in lengths and proportions of the humerus; and it is not at all likely that any two of them belonged, in life, to the same individual. They doubtless belonged to male and female birds of different ages.

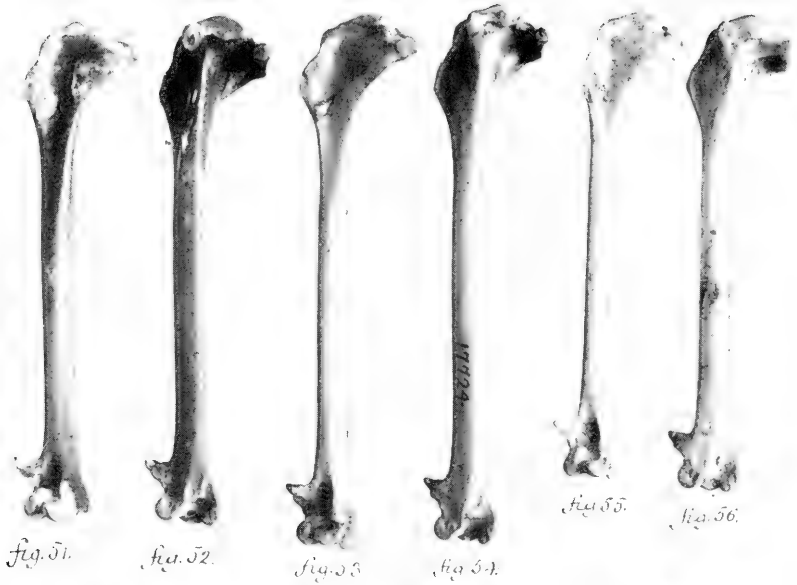


Fig. 51. Fig. 52. Fig. 53. Fig. 54. Fig. 55. Fig. 56.

Fig. 57. Fig. 58. Fig. 59. Fig. 60.

PLATE XXVI.

FIG. 61. Anterior aspect of the *os furculum* of the "Cahow" of the Bermudas (*Æ. vociferans*); subfossil; nat. size. Coll. Amer. Mus. Nat. Hist. (extinct).

FIG. 62. Anterior aspect of the *os furculum* of "*Puffinus major*" (No. 17799, Coll. U. S. Nat. Mus.); nat. size.

FIG. 63. Left lateral view of the pelvis of the "Cahow" of the Bermudas. Adult; nat. size. *Æstrelata vociferans*, sp. nov. Coll. Amer. Mus. Nat. Hist.

FIG. 64. Left lateral view of the pelvis of Audubon's Shearwater (*Puffinus lherminieri*) ("*Puffinus obscurus*," No. 17724, Coll. U. S. Nat. Mus.); nat. size. Compare with Fig. 63 and note the differences between the pelves of a Petrel and a Shearwater.

FIG. 65. Right carpometacarpus of a "Cahow" of the Bermudas. (*Æstrelata vociferans*); nat. size; anconal aspect. From an adult bird. Coll. Amer. Mus. Nat. Hist.

FIG. 66. Right carpometacarpus of the "Cahow" of the Bermudas (*Æstrelata vociferans*). Adult; nat. size; palmar aspect. Subfossil. Coll. Amer. Mus. Nat. Hist.

FIGS. 65 and 66 may or may not have belonged to the same bird; very probably not.

FIG. 67. Right carpometacarpus of *Puffinus parvus*, sp. nov. (extinct). Bermuda Islands. McGall Coll. Anconal aspect; nat. size; adult (sex ?).

FIG. 68. Left lateral oblique view of the os furculum of *Puffinus gavius;* adult; nat. size. (No. 18286, Coll. U. S. Nat. Mus.). Aukland Museum. F. F. Cheeseman, Collector. Barrier Island.

FIGS. 69, 70. Ossa furcula of the "Cahow" of the Bermudas (*Æstrelata vociferans*, sp. nov., extinct); nat. size; left lateral oblique view. Adults. Col. Amer. Mus. Nat. Hist., (sex ?).

FIG. 71. Anconal aspect of the right proximal phalanx of the index digit of the pectoral limb of the "Cahow" of the Bermudas. Nat. size; adult. (*Æ. vociferans*, sp. nov.) Coll. Amer. Mus. Nat. Hist.

FIG. 72. Palmar aspect of the proximal phalanx of the index digit of the left pectoral limb of *Æstrelata vociferans*, sp. nov.; nat. size; adult; subfossil (extinct). Bermuda Islands. Coll. Amer. Mus. Nat. Hist.

FIG. 73. Anconal aspect of the proximal phalanx of the index digit of the left pectoral limb of Audubon's Shearwater (*Puffinus lherminieri*), "*Puffinus obscurus*," No. 17724, Coll. U. S. Nat. Mus., C. Maller, Coll., Bermudas. Nat. size; adult.

FIG. 74. Palmar aspect of the proximal phalanx of the index digit of the right pectoral limb of *Puffinus parvus*, sp. nov. (extinct). Bermudas. McGall collection. Nat. size; adult. Compare with fig. 73.

FIG. 75. Palmar aspect of the pollex digit of the right pectoral limb of the "Cahow" (*Æ. vociferans*, sp. nov. extinct). Nat. size; adult. Coll. Amer. Mus. Nat. Hist.

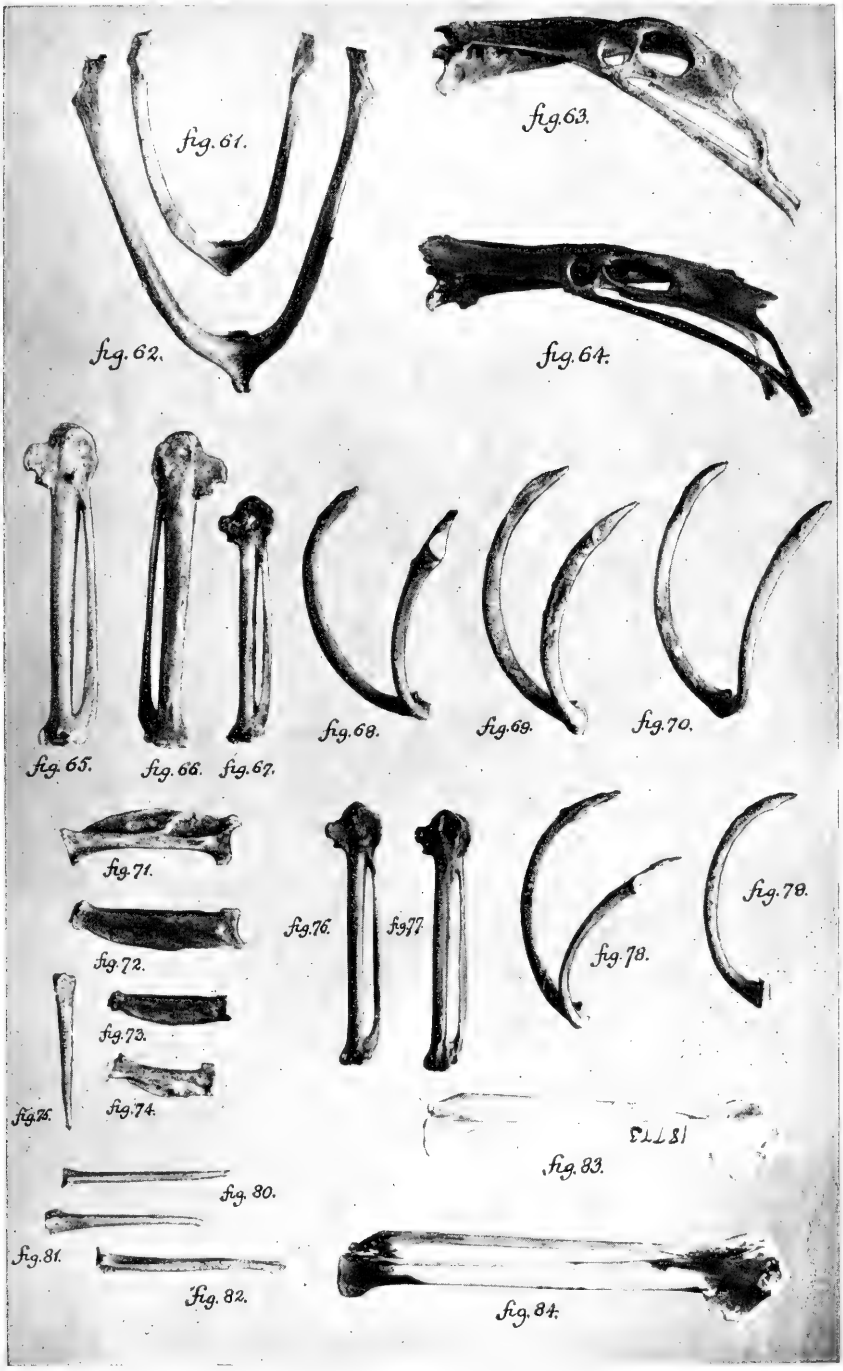


fig. 61.
fig. 62.
fig. 63.
fig. 64.
fig. 65.
fig. 66.
fig. 67.
fig. 68.
fig. 69.
fig. 70.
fig. 71.
fig. 72.
fig. 73.
fig. 74.
fig. 75.
fig. 76.
fig. 77.
fig. 78.
fig. 79.
fig. 80.
fig. 81.
fig. 82.
fig. 83.
fig. 84.

FIG. 76. Anconal aspect of the right carpometacarpus of *Puffinus lherminieri* ("*Puffinus obscurus*"), No. 17724, Coll. U. S. Nat. Mus.; nat. size; adult. C. Maller, collector. Bermudas.

FIG. 77. Palmar aspect of the left carpometacarpus of *Puffinus lherminieri* ("*Puffinus obscurus,*" Coll. U. S. Nat. Mus., No. 17724). See fig. 76.

FIG. 78. Left lateral oblique view of the *os furculum* of *Puffinus lherminieri* ("*Puffinus obscurus,*" No. 17724, Coll U. S. Nat. Mus.). Nat. size; adult. Bermudas.

FIG. 79. Left lateral oblique view of the *os furculum* of *Puffinus parvus,* sp. nov. (extinct). Left limb broken off. Nat. size; adult. Bermudas. McGaii Coll. Sex?

FIGS. 80–82. Terminal digital phalanges of the manus of *Æstrelata vocifcrans* ("Cahow" of Bermuda). Coll. Amer. Mus. Nat. Hist. Nat. size; adult. Figs. 80 and 81 are of the *pollex digit.* (2 individuals; male and female?). Both from right pectoral limbs. Fig. 82, distal phalanx of index digit; right pectoral limb; palmar aspect.

FIG. 83. Palmar aspect of the right carpometacarpus (pectoral limb) of *Puffinus creatopus* (No. 18773, Coll. U. S. Nat. Mus.). Nat. size; adult. Sex?

FIG. 84. Palmar aspect of the right carpometacarpus (pectoral limb) of *Puffinus major.* (No. 17799, Coll. U. S. Nat. Mus.). Adult; nat. size. Sex? See list above.

PLATE XXVII.

FIG. 85. Dorsal view of the *pelvis* of the "Cahow" of the Bermudas. (*Æstrelata vociferans*, sp. nov. (extinct); nat. size; adult. Coll. Amer. Mus. Nat. Hist. Nat. size; adult. Same as fig. 63 of Plate XI.

FIG. 86. Dorsal view of the *pelvis* of *Puffinus lherminieri* ("*Puffinus obscurus*," No. 17724, Coll. U. S. Nat. Mus.). Adult; nat. size. Sex? See fig. 64, Plate XI, where the same bone is shown on side view. Figs. 85 and 86 well show the difference in the pelves of a Petrel and a Shearwater.

FIG. 87. Dorsal view of the *pelvis* of *Puffinus gavius* (No. 18286, Coll. U. S. Nat. Mus.). Nat. size; adult. Barrier Island. (Auckland Museum, F. F. Cheeseman, col.) Typical pelvis of a Shearwater.

FIG. 88. Dorsal view of the *pelvis* of *Puffinus major* (No. 17799, Coll. U. S. Nat. Mus. See list above). Nat. size; adult. Sex?

FIG. 89. Dorsal view of the *pelvis* of *Puffinus creatopus* (No. 18773, Coll. U. S. Nat. Mus.). Nat. size; adult. See list above.

FIG. 90. Anterior view of the left *coracoid* of *Puffinus creatopus;* nat. size; adult. Coll. U. S. Nat. Mus.

FIG. 91. Anterior view of the left *coracoid* of the "Cahow" of the Bermudas (*Æstrelata vociferans*, sp. nov., extinct.). Nat. size; adult. Coll. Amer. Mus. Nat. Hist. There is a small bit broken out of the outer inferior margin.

FIG. 92. Anterior view of the left *coracoid* of the extinct Shearwater, *Puffinus parvus*, of the Bermudas, sp. nov.; nat. size; adult. McGall Coll.

FIG. 93. Anterior aspect of the left coracoid of Audubon's Shearwater (*P. lherminieri*). ("*Puffinus obscurus*," Coll. U. S. Nat. Mus., No. 17724.) Nat. size; adult. Sex?

FIG. 94. Ventral aspect of a right *scapula* of the "Cahow" of Bermuda, *Æstrelata vociferans;* nat. size; adult. Sex? Coll. Amer. Mus. of Nat. Hist.

FIG. 95. Ventral view of the left *scapula* of *Puffinus lherminieri* (No. 17724, Coll. U. S. Nat. Mus.). Nat. size; adult. See fig. 93 of this plate.

FIG. 96. Dorsal view of a right *scapula* of the "Cahow" of Bermuda (*Æ. vociferans*, sp. nov., extinct). Coll. Amer. Mus. Nat. Hist.; nat. size; adult.

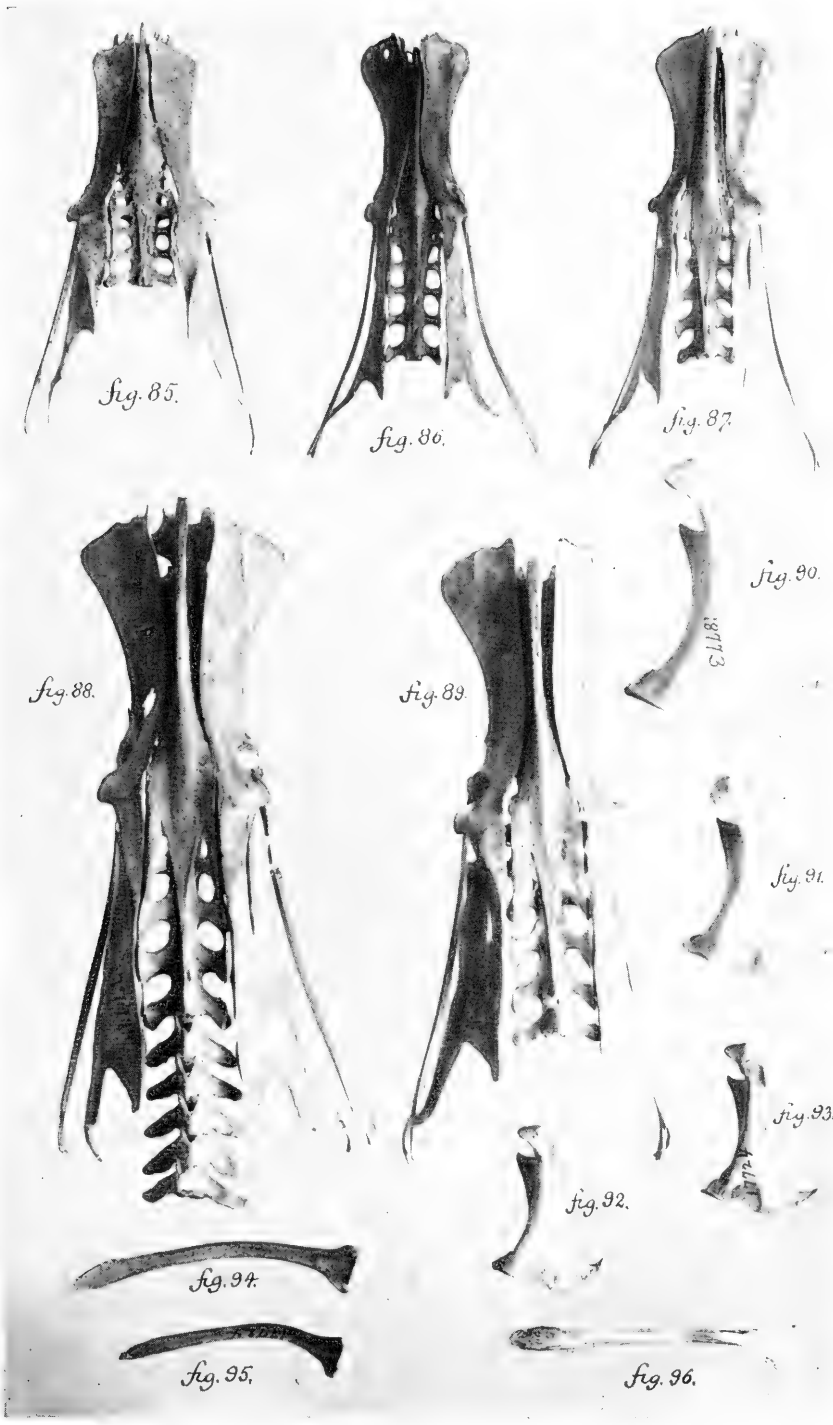


Fig. 85.
Fig. 86.
Fig. 87.
Fig. 88.
Fig. 89.
Fig. 90.
Fig. 91.
Fig. 92.
Fig. 93.
Fig. 94.
Fig. 95.
Fig. 96.

PLATE XXVIII.

FIGS. 97–100. *Femora* of the "Cahow" of the Bermudas, *Æstrelata vociferans*, sp. nov. (extinct); nat. size; adults. Different individuals. Coll. Amer. Mus. Nat. Hist. Fig. 97, right pelvic limb, anterior view; fig. 98, left, posterior view; fig. 99, left, posterior view, and fig. 100, mesial view of a right femur.

FIG. 101. Mesial aspect of the right *femur* of *Puffinus gavius*. Adult; nat. size. Sex? (No. 18286, Coll. U. S. Nat. Mus.). Auckland Museum. Barrier Islands. F. F. Cheeseman, col.

FIG. 102. Mesial aspect of the right *femur* of *Puffinus lherminieri*. (No. 17724, Coll. U. S. Nat. Mus.) Nat. size; adult. Sex?

FIG. 103. Left *femur*, anterior aspect, nat. size, Audubon's Shearwater. Same skeleton as fig. 102.

FIG. 104. Anterior view of the left *femur* of *Puffinus major*. Nat. size; adult. (No. 17799, Coll. U. S. Nat. Mus.). See list.

FIG. 105. Mesial aspect of the right *femur* of *Puffinus major;* from the same skeleton as fig. 104; nat. size.

FIG. 106. Anterior aspect of the right *tarsometatarsus* of *Puffinus lherminieri* (No. 17724, Coll. U. S. Nat. Mus.). Nat. size; adult.

FIG. 107. Anterior aspect of the right *tarsometatarsus* of *Puffinus parvus*, sp. nov. (extinct). Bermudas. McGall Coll. Nat. size; adult.

FIGS. 108–111. *Tarsometatarsi* of the "Cahow" of the Bermudas, *Æstrelata vociferans*. Nat. size; adult. Coll. Amer. Mus. Nat. Hist. Fig. 108, right limb, outer aspect; fig. 109, right limb, anterior aspect; figs. 110 and 111, left limbs, posterior aspects, showing slight individual variation. (New species; extinct.)

FIG. 112. Anterior view of the left *femur* of *Puffinus creatopus*. (No. 18773, Coll. U. S. Nat. Mus.) Nat. size; adult.

FIG. 113. Mesial aspect of the right *femur* of *Puffinus creatopus*. From same skeleton as fig. 112.

FIG. 114. Outer aspect of the left *tarsometatarsus* of *Puffinus major*. (No. 17799, Coll. U. S. Nat. Mus.) Nat. size; adult. Sex? See list.

FIG. 115. Anterior view of the right *tarsometatarsus* of *Puffinus major;* nat. size. Same skeleton as fig. 114.

FIG. 116*a*. Direct anterior view of the right *tibiotarsus* of *Puffinus gavius*. Nat. size; adult. No. 18286, Coll. U. S. Nat. Mus. Barrier Island. F. F. Cheeseman, collector. Auckland Museum.

FIG. 116*b*. Direct external aspect of the left *tibiotarsus* of the same skeleton to which the bone shown in fig. 116 belonged, *Puffinus gavius*.

FIG. 117*a*. Semi-oblique anterior view of the right *tibiotarsus* of *Puffinus lherminieri* ("*Puffinus obscurus*"), No. 17724, Coll. U. S. Nat. Mus., Bermudas. C. Maller. Nat. size; adult.

FIG. 117*b*. Direct external aspect of the left *tibiotarsus* of the same skeleton to which the bone shown in fig. 177*a* belonged, *Puffinus lherminieri*.

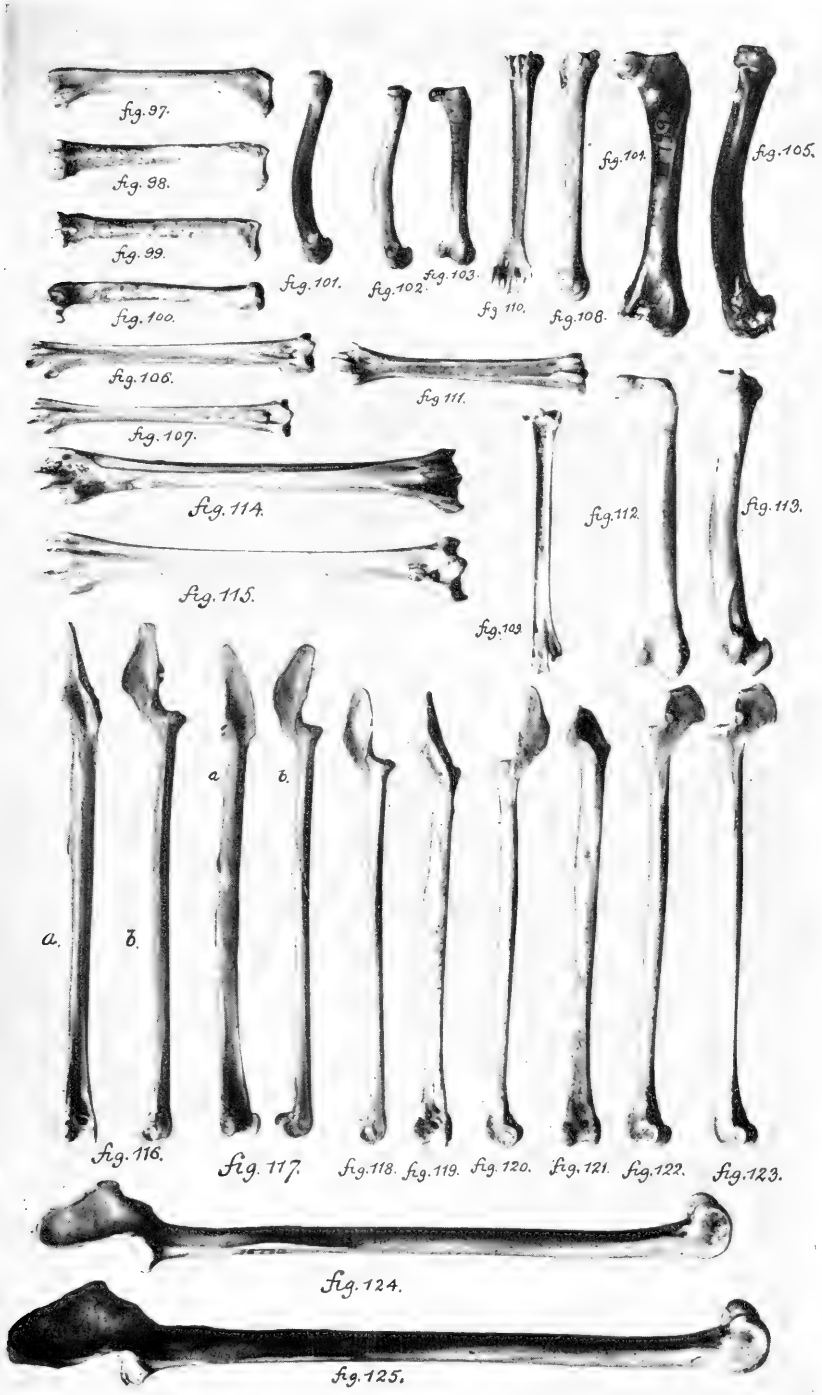


fig. 97.
fig. 98.
fig. 99.
fig. 100.
fig. 101.
fig. 102.
fig. 103.
fig 110.
fig. 108.
fig. 104.
fig. 105.
fig. 106.
fig. 107.
fig. 111.
fig. 114.
fig. 115.
fig. 109
fig. 112.
fig. 113.
a.
b.
a.
b.
fig. 116.
fig. 117.
fig. 118.
fig. 119.
fig. 120.
fig. 121.
fig. 122.
fig. 123.
fig. 124.
fig. 125.

FIG. 118. Outer aspect of the left *tibiotarsus* of *Puffinus parvus* (n. sp., extinct). Nat. size; adult. Coll. Amer. Mus. Nat. Hist.

FIG. 119. Direct anterior aspect of the right *tibiotarsus* of *Puffinus parvus* (n. sp., extinct). Nat. size; adult. McGall Collection.

FIG. 120. Direct inner aspect of the left *tibiotarsus* of *Puffinus parvus* (n. sp., extinct). Nat. size; adult. McGall Collection.

FIG. 121. Anterior aspect of a right *tibiotarsus* of *Æstrelata vociferans*. Nat. size; adult. McGall Collection.

FIGS. 122, 123. Direct inner views of *tibiotarsi* of *Æstrelata vociferans*. Nat. size; adults. Exhibiting little or no individual variation. Coll. Amer. Mus. of Nat. Hist.

FIG. 124. External aspect of the right *tibiotarsus* of *Puffinus creatopus*. Nat. size; adult. (No. 18773, Coll. U. S. Nat. Mus.)

FIG. 125. External aspect of the right *tibiotarsus* of *Puffinus major*. (No. 17799, Coll. U. S. Nat. Mus.) Nat. size; adult.

PLATE XXIX.

FIG. 126. Direct left lateral view of a mounted skeleton of a *Puffinus* in the collection of the Museum of Comparative Zoölogy, Harvard University (No. 1429). Catalogued as "*Œstrelata lessoni*"; labeled as "*Procellaria lessoni*, White-headed Petrel," adult. Length of skull in life 6.6 cms. Length of humerus 6.2 cms. These measurements will give the amount of reduction in the figure.

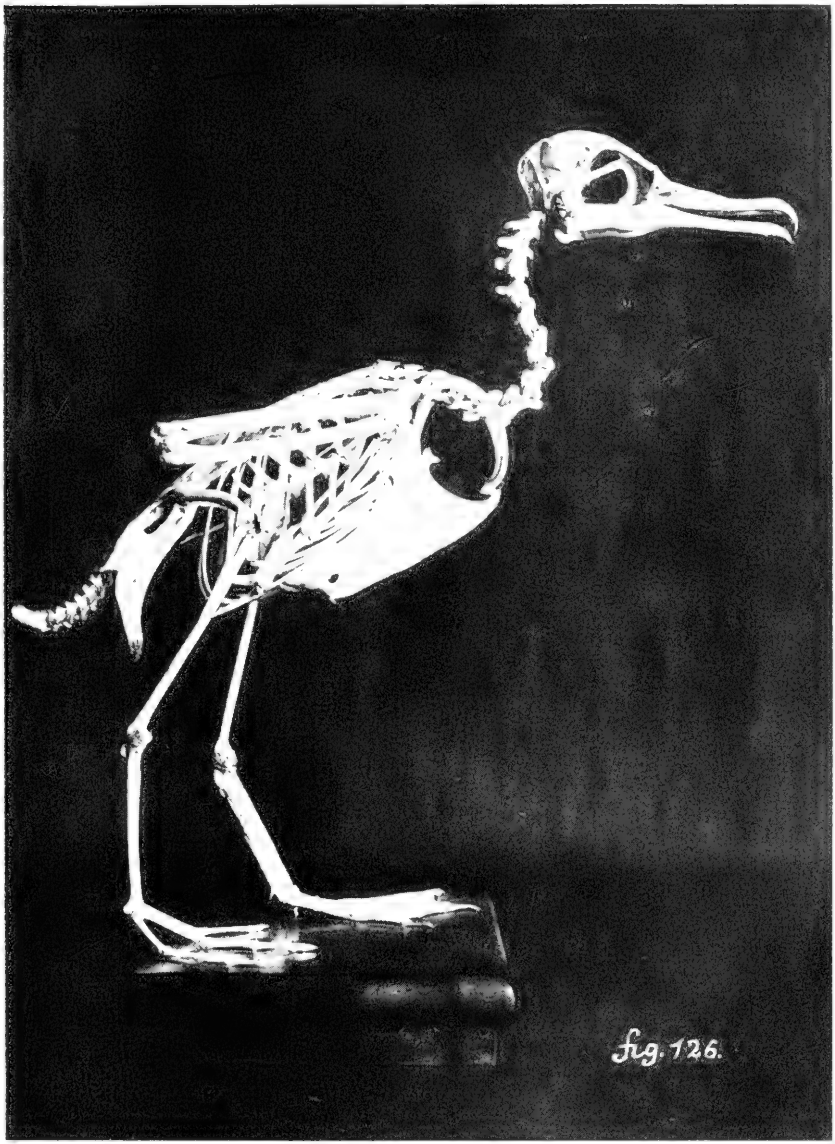


fig. 126.

PLATE XXX.

FIG. 127. Very nearly direct anterior view of the same skeleton as shown in fig. 126 of Plate XXIX. Slightly reduced. The skull and leading nine cervical vertebræ are larger in proportion than the rest of the skeleton owing to being nearer the lens when photographed.

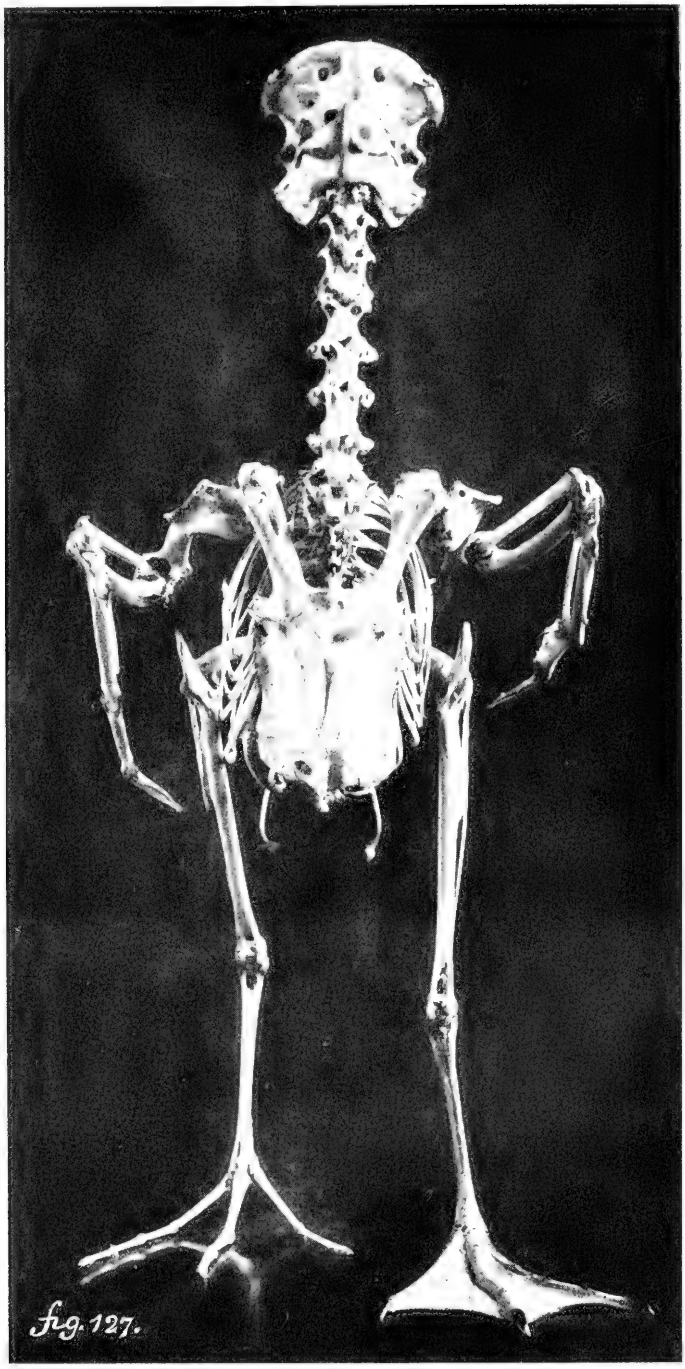


Fig. 127.

PLATE XXXI.

FIG. 128. Right lateral view of the head of an Audubon's Shearwater (*Puffinus lherminieri*). Nat. size; adult ♀. No. 223116, Coll. U. S. Nat. Mus. From the collection of Bradshaw H. Swales. May 4, 1889. Bahamas. D. P. Ingraham, Collector. Photo of the skin by the author.

FIG. 129. Right lateral view of the head of an *Æstrelata caribbæa*. Nat. size; adult ♂. (No. 80860, Coll. U. S. Nat. Mus.) E. Newton, Nov. 17, 1879, Cinchona Plantations, St. Andrews, West Rock, Jamaica. Photo of the skin by the author.

FIG. 130. Right lateral view of the head of *Æstrelata hasitata* ♀. (No. 152522, Coll. U. S. Nat. Mus.) (Aug., 1893.) Photo of the skin by the author.

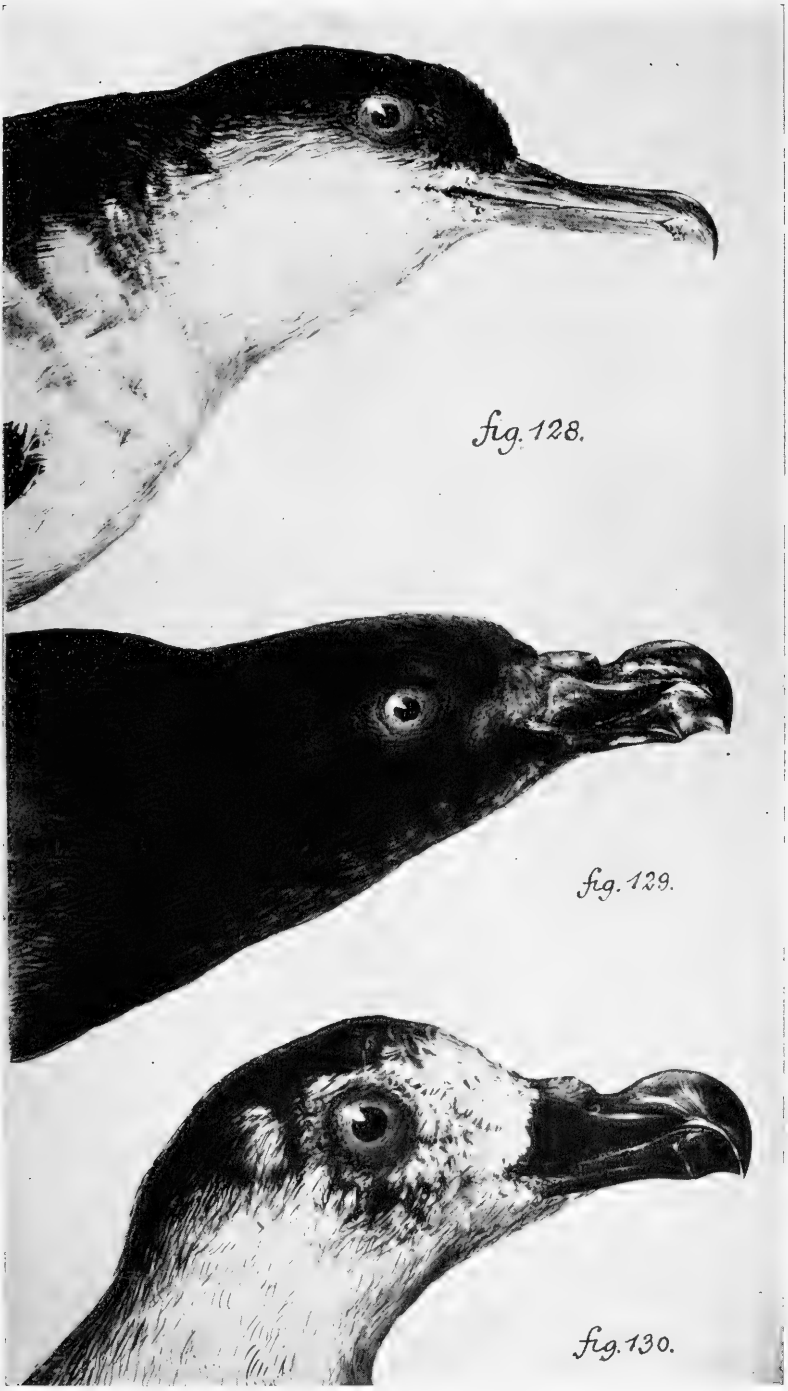


fig. 128.

fig. 129.

fig. 130.

XII. THE VIGILANT FIRE-ENGINE.

By W. J. Holland.

(Plate XXXI.)

A very interesting event was the arrival at the Carnegie Museum on June 24, 1920, of the old fire-engine "Vigilant."

The formal act of presentation was preceded by a parade, which moved from the City Hall to the Museum. The order of parade was as follows:

1. Mounted Police Squad.
2. Mayor, Council, and Director of the Department of Public Safety in automobiles.
3. Chief Miles S. Humphreys, John McElroy, and other veterans in automobiles.
4. Band of music.
5. Chief of Bureau of Fire and associates in automobiles.
6. The Vigilant Engine, drawn by veteran firemen.
7. Single pump steam fire-engine drawn by two horses.
8. Triple Combination Gasoline Pumper, three in one, self-propelled (the latest and most perfect type of fire-engine).

The presentation ceremony took place at the main entrance of the Carnegie Institute. Mr. T. E. Jones, Chief Clerk of the Bureau of Fire, presided and introduced the speakers. Mr. Miles S. Humphreys, Chief of the Fire Department of the City of Pittsburgh from August, 1891, to April, 1913, on behalf of the veterans and present firemen of Pittsburgh, made the presentation address. He said:

"*Dr. Holland:* Before you is an assemblage of old-time and present firemen, who have gathered for the purpose of placing in the Carnegie Museum, of which you are the honored Director, an interesting relic of the past.

"During the early development of our country, our Commonwealth, and its towns, the methods devised and used for combating the devastating and destructive results of fire were not only varied, but exceed-

ingly crude and inefficient. To improve these conditions volunteer companies were formed, not only in order to devise improved methods and apparatus, but also to be at all times ready to lend a hand in saving property and life. In this matter Pittsburgh was ranked among the foremost American cities and recognized as having many of the best organizations. The membership was composed of men who in their day adorned the bench, the bar, the pulpit, and other professions, and were prominent leaders in commerce and manufactures. When the occasion required they were at all times stalwart defenders of the flag of their country.

"As the years went by, inventive genius set aside the cistern and hand-pump and provided water by means of gravitation, which, aided by leather hose and the concentrated man-power of the hand-engine, made the bucket-brigade a thing of the past. Then came the steam-engine and knitted and woven cotton hose. As towns grew into cities paid fire departments with fixed rules and regulations were instituted, and, as a result, volunteer organizations in many localities became extinct. When the steam fire-engine appeared the hand-engine vanished. One by one they were sold or given away to smaller municipalities. These in turn, as they grew in population, secured more modern apparatus, and the hand-engine, with rare exceptions, was thrown upon the junk-pile. The citizens of Pittsburgh gradually allowed all their old hand-engines to pass out of their possession, and when in after years memories of the past awoke a desire to secure and preserve one of them as a memento and relic of former times, it was discovered that only one or two could be located, and these were so firmly held that they could not be obtained upon any conditions.

"Within the last few months we fortunately have come into possession of the last hand-engine bought and owned by the old Vigilant Volunteer Fire Company. This company was formed in 1811 and was one of the most famous of the early volunteer organizations of the city. Its first president was William Wilkins, one of the leading citizens of those days, who held many prominent positions, including those of United States Senator, Secretary of War, and Minister of the United States to Russia. From and including the time of its formation until the day of its dissolution the names of many men of local prominence appear upon its roster. In their time, too, a number of

fire-fighting equipments were purchased by them, the latest being the engine we have with us today.

"This engine was built in 1850 by the then famous builder of hand-engines, John Agnew, of Philadelphia, and was claimed to be the best constructed and most highly finished engine ever turned out of his shops. More than ten years afterwards, in the early sixties, it appears that this company supplanted it by a steam fire-engine, the first ever brought to this city. The steam fire-engine was later transferred to the municipality when it took over the assets of the volunteer companies. The hand-engine was sold to Salem, Ohio. In the course of time the people of Salem secured an improved engine. At the time of the Centennial Celebration of Allegheny County they brought, or sent, the Vigilant engine to Pittsburgh, where it was one of the leading features of the exhibition. While here it was noticed by a member of the Veteran Volunteer Firemen's Association of Philadelphia, who was present, and by him it was quietly purchased from the authorities of Salem, and at once spirited away to the Quaker City. There the old boys had it repainted, and the iron-work nickle-plated, and for more than three decades they in their old-time uniforms with the engine attended many of the annual firemen's conventions and tournaments, which were held throughout Pennsylvania, New York, and New England. 'Time,' however, 'like an ever-rolling stream, bears all its sons away,' and through the inexorable decree of death, coupled with the infirmities incident to old age, the membership of the firemen's organization in Philadelphia has been so reduced in numbers that the remaining few decided to disband. While deliberating over their dissolution and considering what should be done with their accumulated relics, in recognition of the fact that the original home of the Vigilant engine was Pittsburgh, they unanimously agreed to tender it to the care and keeping of the firemen of this city. The gracious tender was accepted and two of our oldest firemen went on to Philadelphia and brought it here. Now we are all of the undivided opinion that its proper place is in this famous Museum, and to that end, as I have said, we have brought it here with the request that you accept and place it in a position where to the thousands of the future, as to those of the present, who come and go, it will stand as a mute emblem of the means used in fighting fires in the days of yore."

After the address of Mr. Humphreys, the Director of the Museum in a few words accepted the gift on behalf of the Trustees of the Institute, who had by resolution of the Committee on the Museum in anticipation of the gift signified their pleasure to receive the same.

His Honor, Mayor Edward Vose Babcock, made a brief speech to the large company which had assembled, and he was followed by Mr. William H. Stevenson, President of the Historical Society of Western Pennsylvania.

After the ceremony of presentation the "Vigilant" was taken to the inner court of the Institute and raised on the freight elevator to the third story of the Museum, where it was placed at the point assigned for its reception by the Director, among other historic relics of Pittsburgh.

At the instance of Captain George W. King, the Veteran Firemen's Association of Pittsburgh has donated a collection of hats formerly worn by the volunteer firemen of the city, as well as a number of axes, belts, and other articles used in former years. Two exhibition cases have been built in which these objects are exhibited on either side of the "Vigilant" engine.

PLATE XXXII.

1. Mr. John Hays.
2. Captain George King.
3. Mr. Frank Dorrington.
4. Mr. David D. Jones.
5. Mr. John McElroy.
6. Mr. Miles S. Humphreys. (Former Chief of Fire Dept. of Pittsburgh.)
7. Dr. W. J. Holland.
8. .....
9. Mr. J. Stater.
10. Mrs. J. Stater.
11. Mr. John P. Irwin.
12. Mr. William H. Sharrah.
13. Mr. William McClelland.
14. .....
15. Mr. W. H. Lenhart.
16. Mr. Matthew Sloane.
17. Mr. Wm. H. Stevenson.
18. Mr. William Bennett. (Chief of Fire Dept. of Pittsburgh.)
19. Mr. Thomas Pfarr. (Fire Marshal.)


VIGILANT

XIII. SOME NOTES ON SPHÆRIIDÆ WITH DESCRIPTIONS OF NEW SPECIES.

By Victor Sterki.[1]

Among the Sphæriidæ examined by me during the year 1919 there were an unusual number of forms possessing interest in regard to their systematic position and distribution, and there are also some new species and forms.

At the Biological Station of the University of Michigan, on Devils Lake, North Dakota, as headquarters, Miss Mina L. Winslow, of the Museum of Zoölogy, and other collectors have secured some good material, which they sent me for examination. It mainly consists of *Sphæriidæ, Vallonia,* and *Pupillidæ.* I mention some of their sendings in the following paragraphs.

1. Vicinity of Devils Lake, North Dakota: *Pisidium tenuissimum* Sterki, a very small form from several unnamed lakes, and from Court Lake; *P. tenuissimum calcareum,* a form frequent to common, occurring fossil in the marls of Maine, Michigan, and Illinois, but now for the first time represented by recent specimens; a few specimens of *P. vesiculare,* a small form from the same localities.

2. Turtle Mountains, North Dakota, from which nothing had been before this reported: *P. variabile, pauperculum, contortum* Prime, the last mentioned not before seen from west of Michigan; *P. apiculatum* n. sp. (see *infra,* Description No. 7); and an exceptionally small form of *P. compressum* Prime.

3. There are six separate lots taken from the Sheyenne River at various places. Of particular interest are *Sphærium declive* n. sp. (see *infra,* Description No. 12); *S. sulcatum* Lamarck, the same form as from South Dakota; a few valves of a small *Sphærium,* apparently *stamineum* Conrad, which call for more specimens for their exact determination; *Musculium jayense* Prime. Most of the specimens

[1] This paper is part of a report submitted to the Director of the Carnegie Museum about the beginning of the year 1920.

are recognizable, though rather small. A number are more or less deformed and crippled, though probably the same; a few are markedly different, and are apparently *S. truncatum* Linsley.

4. Sent with the preceding from the vicinity of Lake Cushman, Mason County, Washington, collected by Mrs. Helen T. Gaige, are some *Sphæriidæ* of particular interest. I shall first mention *Sphærium patella* Gould from several localities. The original description of this species, as cited by Prime in *Mon. Corb.,* p. 42, is evidently based upon quite immature specimens: long. 10.75; lat. (=alt.) 7.75; diam. 4.5 mm. Those before me range from smaller sizes, than those just given, to specimens 15 to 16 mm. long, and still larger individuals have been seen before from other places. *Pisidium variabile* Prime, apparently like eastern forms, and markedly different from the form *magnum* from other places in Washington. For *P. notophthalmi* n. sp., (see *infra,* Description No. 8). *P. columbianum* Sterki was sent, an exceptionally small form and otherwise somewhat different, having the beaks markedly flattened on top.

Included in a sending received from Dr. Bryant Walker was a lot of shells from the beach-drift of Saginaw Bay, Lake Huron, collected by Mr. Calvin Goodrich, including several forms of *Sphærium* spp., which furnish valuable aid in studying the *Sphæria* of the Great Lakes. Among them are several peculiar forms, which can not be identified with those now known. More good material from all of the Great Lakes, especially material taken by dredging, is very desirable. In the lot were numerous specimens, mostly young and immature, identified as *P. amnicum* (form *striolatum* Baudon ?) from Lake Ontario, supposed to have been introduced from Europe. One young shell of the same form has also been seen from beach-drift at the southern end of Lake Michigan. This may reopen the question whether the species is indigenous in North America. So far as is known it has not been found fossil on this continent. If the mussels were colonized in Lake Ontario, they may well have spread to the upper lakes. It may be added that repeated careful comparison has shown that the mussel from Lake Ontario is identical with specimens from England, France, and Germany, while other forms of *amnicum* are rather different.

Mr. S. Stillman Berry has sent a number of lots collected by him in 1919 and in former years. One rather remarkable lot is from Lake Winnecook, Unity, Maine, collected in 1909. It surprised me to receive from a locality in New England a faunula comprising peculiar forms of known species and quite a number of new species. I refer at the outset in what follows to the material sent me by Mr. Berry from his collections made in Maine.

P. æquilaterale Prime, differing from most other forms by the less elevated beaks and generally more rounded outlines; *P. pauperculum nylanderi* Sterki, somewhat different from the same from other places in New England (over three hundred specimens); *P. ferrugineum* Prime, less inflated than the usual form and with the ridges on the beaks strongly developed. (For *P. deflexum, compressum mutatum, decisum, paradoxum,* and *griscolum,* n. spp., and forms, consult *infra,* Descriptions Nos. 1–5.) It must be regarded as even more remarkable that among the five hundred specimens sent me there were none of the many species known to occur in New England, some even in the same part of Maine, with the exception of the three mentioned above at the beginning of this paragraph. There were no specimens of *P. compressum,* typical, and the New England form *curvatum, variabile, sphæricum, abditum, splendidulum, rotundatum, ventricosum,* and a dozen others. It certainly would be worth while to thoroughly explore that whole vicinity in order to determine the ecological and systematic significance of its fauna. Some interesting forms of *Musculium* and *Sphærium* should also be found there.

Mr. Berry also sent me some material collected near Iceberg Lake, Glacier National Park, Montana, in the year 1910. A few specimens appear to be identical with *P. marci* Sterki from Utah. I describe as new a species collected by Mr. Berry in Elk Creek, Meagher County, Montana, in the year 1914, *P. limpidum* Sterki (see *infra,* Description No. 6).

From the same correspondent I received a number of lots of *Pisidia* collected in southern California, mainly in the San Bernardino Mountains, during the years 1908–1919. In order to their exact determination closer examination and comparison is necessary.

In the same sending there were a number of *Pisidia* collected by A. W. Hanham at Quamishan, British Columbia, among them *P. columbianum* Sterki. Two species from this locality I have described

as new, *P. prognathum* and *P. pilula* (see *infra,* Descriptions Nos. 10–11).

In 1918 and 1919 Mr. Carl C. Engberg, of Lincoln, Nebraska, collected some *Pisidia* on Orcas Island, San Juan County, Washington. Among the several species and forms it may be noted that *P. abortivum exiguum* Sterki was found at several places, and seems to be common and even abundant, but not a single typical *P. abortivum* was collected, while in the Bitter Root Valley, Montana, the latter were predominant, only a few of the form *exiguum* occurring. The mussels have regular, elliptic outlines, and are strongly inflated, globular, rather variable in size (from 2.2 to 1.6 mm. long when full grown), and with nepionic young. It appears that this smaller form is distributed all along the Pacific Slope, and it may be the really typical form, and the larger, less inflated form, possessing somewhat different outlines (*abortivum*) may be specially developed.

I have described as new one of the species collected by Mr. Engberg, calling it *P. orcasense* (see *infra,* Description No. 9).

In the same lot were some other specimens, which may possibly represent undescribed species, but there is not enough material at hand to seem to justify their description as new. It may be proper to state that with this material there was a single minute *Musculium,* 2.6 mm. long, nearly globular, but apparently immature.

With other material, Dr. Frank C. Baker has sent two specimens, labeled "Alaska." One of them was *P. idahoense* Roper, much like the large form from Seattle, Washington, 10 mm. long, with six or seven strongly marked rest-lines. Other specimens of so-called *idahoense* from localities in Alaska are markedly different, more like the form *indianense,* and it is possible that the two forms represent distinct species, as has been suggested by some malacologists. The other specimen sent by Mr. Baker was *Sphærium tenue* Prime, well formed, 6.2 mm. long.

Other correspondents in the western parts of the country have made collections and sent in specimens, which demand further careful study

and comparison before reporting upon them. It is worthy of observation that the Pacific region from Alaska and British Columbia to southern California is remarkably rich in Sphæriidæ, most of them being different from the eastern species. Every sending from the western coast reveals new forms. The fauna as a whole is still insufficiently and only fragmentarily known. Some of the species appear to be so variable that it is difficult to define them. In consequence I am in doubt whether some of them represent local forms, regional subspecies, or distinct species. I may add that there are in my hands some manifestly new and distinct species, which are not, however, represented by sufficient numbers of specimens to justify me in publishing them as such for the present. This fact may mean disappointment to the collector who has sent in his specimens and requests that they be "named." Nevertheless every good lot of specimens from the Pacific coast, or, for that matter, from any locality whatsoever, means a contribution to the understanding of the interrelations of the species and forms of this intricate group of the Pelecypoda, their variation, and their geographical distribution.

DESCRIPTIONS OF NEW SPECIES AND FORMS OF PISIDIUM AND SPHÆRUM.

1. *Pisidium deflexum* n. sp. Mussel inequipartite, oblique, well inflated, anterior part markedly larger and directed downward, the superior and inferior margins being at an angle; superior margin slightly curved and merging into the anterior in a rather long continuous curve as far as the rounded anterior end, which is well below the median line; posterior margin truncate or subtruncate obliquely anteriorly, forming a well-marked angle with the superior, passing into the inferior margin without an angle; beaks rather posterior, broad, rounded, or slightly flattened, not greatly projecting over the dorsal margin; surface dull glossy, with fine, somewhat sharp and irregular striæ and a number of rest-lines; color grayish to yellowish corneous, alternating with narrow dark zones, mostly along the rest-lines; shell rather thick, opaque; hinge stout, somewhat like that of *compressum,* but the plate is longer and the laminæ, especially the anterior, diverging at smaller and more rounded angles; the right cardinal is less sharply curved, with a deep excavation below. Long. 3.5; alt. 3; diam. 2.3 mm.

Habitat: Lake Winnecook, Unity, Maine. Collected by S. Stillman Berry in 1909. There were eighteen specimens in the lot, from young to mature; in size and appearance much like *compressum mutatum,* with which it is associated, but the two are plainly separable.

Type No. 9212, C. M.; paratypes in the collection of Mr. S. Stillman Berry.

2. *Pisidium compressum mutatum* n. subsp. The superior margin is comparatively long and slightly curved, the supero-anterior slope steep, long, straight or nearly so; the beaks are less elevate, broader, with low, but sharp, ridges almost entirely surrounding a rather large flattened central area on each; surface with a somewhat silky gloss produced by very fine, crowded, sharp, irregular striæ; color grayish to plumbeous; shell subtranslucent; hinge stout, of the general configuration of the species, the plate rather longer; mussel rather small. Long. 3.2; alt. 3; diam. 2 mm.

Habitat: Lake Winnecook, Unity, Maine. Collected by S. Stillman Berry in 1909. Specimens ranging from young to mature (see notes under the preceding species). Type No. 9211, C. M.; paratypes in the collection of Mr. S. Stillman Berry.

This *Pisidium* is markedly different from all of over a dozen named and described forms and subspecies of *compressum,* including those seen from New England and New York. If no intermediate and connecting forms are found, it should be regarded as a distinct species.

3. *Pisidium decisum* n. sp. Mussel subequipartite, short, slightly oblique, well inflated, mostly so above the middle; superior margin rounded, supero-anterior slope well marked, rather steep, straight, anterior end rounded angular, well below the median line, posterior margin truncate at right angles, inferior well curved; beaks slightly posterior, large, rounded, somewhat projecting over the hinge-margin; surface polished, with very fine and slight concentric striæ, some spaces smooth, with very fine scratch-like lines; color corneous to drab to olive, with a lighter zone along the margins, light to dark brown in old specimens; shell rather thick, translucent to opaque; hinge stout, rather long, plate broad, short, with the cardinals on its upper part, the right not much projecting, sharply curved in the middle, its anterior part short, the posterior long, grooved to bifid; left anterior somewhat oblique, angular, bent upward, its free edge sharply rounded or pointed, the posterior long, oblique, slightly

curved; laminæ at marked angles to the plate, massive, the right inner both with their cusps about in the middle, obtusely angular, not abrupt; outer anterior nearly half as long, the posterior less than one-third as long as the inner, left both with their cusps markedly larger, pointed, somewhat more abrupt; ligament short, thick. Long. 3.5; alt. 3.4; diam. 2.6 mm. Long. 2.8; alt. 2.8; diam. 2 mm. (apparently mature).

Habitat: Lake Winnecook, Unity, Maine. Collected by S. Stillman Berry in 1909. There were twenty-two specimens in the lot, ranging from young to old, and remarkably uniform, except that in a few old ones the supero-anterior slope and the posterior margin are slightly curved.

In shape and appearance the mussels somewhat resemble *P. variabile,* especially immature examples of the form *cicer,* but are much smaller and easily distinguished; the young are of a different shape from those of *variabile.*

Types No. 9214, C. M.; paratypes in the collection of Mr. S. Stillman Berry.

4. *Pisidium paradoxum* n. sp. Mussel of medium size, somewhat inequipartite and oblique, moderately elongate, moderately inflated, having somewhat oval outlines; superior margin nearly straight, bounded by slightly marked angles anteriorly and posteriorly, the other margins rounded, the supero-anterior slope barely marked in the adult, somewhat more so in the young; beaks slightly posterior, rather small, moderately projecting, rounded; surface with a somewhat silky gloss, striæ irregular, crowded, very fine, sharp, some of them with the periostracum slightly projecting, scale-like; color uniformly pale corneous to drab; shell very thin, subtranslucent; hinge slight, plate narrow; right cardinal with its anterior part nearly straight and longitudinal, close to the valve-margin, thin, the posterior part abruptly bent down, short, strongly bifid, the anterior (or inner) shank forming a hook, the posterior standing out somewhat wing-like; left cardinals small and short, far apart posteriorly, the anterior nearly straight and longitudinal, the posterior oblique; laminæ rather slight, the inner of the right valve with the cusps small, pointed, about median, the outer anterior placed proximally, about one-fourth the length of the inner, the posterior nearly half as long as the inner, both left laminæ with the cusps small, pointed, the anterior abrupt,

the posterior distally more so; ligament moderately long, slight. Long. 4; alt. 3.5; diam. 2.5 mm. Soft parts not examined.

The young mussels are very little inflated, with the small, narrow beaks projecting, the shells colorless, glassy, transparent; the right cardinal is slightly curved, and its posterior end little thicker, but distinctly bifid.

Habitat: Lake Winnecook, Unity, Maine. Collected by S. Stillman Berry, Aug., 1909. About forty specimens were seen, only a few of them mature, or nearly so.

Type and paratypes No. 9215, and seqq., C. M.; paratypes in the collection of Mr. S. Stillman Berry.

This is a rather remarkable species. In spite of its commonplace appearance, it is so different from others, especially in regard to the formation of the cardinals, that it is difficult to assign it to any of the more or less well-established groups. In fact, the right cardinal is rather like that of forms of *Musculium*, but otherwise the mussel is a true *Pisidium*. It should be noted that the configuration of the hinge was the same in two specimens opened; so it is not a case of individual deformity.

5. *Pisidium griseolum* n. sp. Mussel small, subequipartite, slightly elongate, moderately inflated; superior margin nearly straight, bounded by an angle posteriorly and a more obtuse angle anteriorly; supero-anterior slope somewhat marked, moderately oblique; posterior margin truncate or subtruncate at nearly right angles, inferior moderately curved; beaks barely behind the middle, rather small, rounded, or slightly flattened on top, not very prominent; surface dull glossy, with very fine, somewhat irregular striæ; color pale corneous to light grayish; shell thin, translucent; hinge rather long and stout, plate rather broad; cardinals short, rather well up on the plate, the right angular in the middle, its posterior part thicker and grooved, left both of about the same size, the anterior angular, its edge sharply pointed, posterior oblique, slightly curved; laminæ somewhat massive, the right anterior with its cusp about median, pointed, not abrupt, posterior with cusp somewhat distal, abrupt distally, outer both rather large, about half as long as their principals; left both with cusps about median, pointed, not very abrupt; ligament rather short and thick. Long. 2.8; alt. 2.3; diam. 1.5 mm.

Habitat: Lake Winnecook, Unity, Maine. Collected by S. Still-

man Berry, July, 1909. About thirty specimens were in the lot, ranging from young to mature. Types No. 9218, C. M.; paratypes in the collection of Mr. S. Stillman Berry.

This modest and rather inconspicuous *Pisidium* can not be referred to any of the described species, and can not be mistaken for another. Similar specimens have been seen before and set aside with a query—*c. g.,* some from Lynnfield, Massachusetts, collected by H. W. Winkley in 1910, C. M., No. 6645. The color of these is yellowish corneous, and the hinge is slightly different.

6. *Pisidium limpidum* n. sp. Mussel small, subequipartite, short and oblique, moderately inflated; superior margin short, rounded, supero-anterior slope from closely in front of the beaks, somewhat curved, rather steep and long as far as the rounded angular anterior end well below the longitudinal axis; posterior end truncate at right angles, passing into the regularly curved inferior margin without an angle; beaks little projecting over the hinge-margin, slightly flattened laterally near the center, so as to appear almost pointed and closely approximate in frontal (or rear) view; surface polished, with the concentric striæ very slight, irregular; shell glassy transparent, colorless when fresh, with a faint yellowish tinge when dry, and a whitish zone along the margins; hinge rather stout, curved-angular, plate short, rather broad; right cardinal long, longitudinal, moderately curved in the middle, its posterior end somewhat thicker and slightly grooved to bifid; the left ones rather small, slight, the anterior nearly straight, its edge pointed, the posterior oblique, slightly curved; laminæ stout, their cusps about in the middle, obtusely pointed, not abrupt; outer ones about one-third the length of the inner, rather thick; left ones with their cusps about in the middle, large, pointed, not very abrupt; ligament rather short and thick. Long. 2.5; alt. 2.3; diam. 1.8 mm.

Habitat: Elk Creek, one mile south of Oxford Station, Meagher Co., Montana. Collected by S. Stillman Berry, June, 1914. There were over forty specimens in the lot, most of them gravid. They somewhat resemble forms of *pauperculum,* but are distinct, differing especially in the features of the hinge.

Type and additional specimens in C. M., No. 9198 and seqq.; paratypes in the collection of Mr. S. Stillman Berry.

7. *Pisidium apiculatum* n. sp. Mussel inequipartite, oblique, well

to strongly inflated; upper margin short, curved, bounded by an obtuse angle to the supero-anterior slope, which is straight or nearly so, anterior end rounded angular, posterior margin well rounded, forming one continuous curve from the beaks to the anterior end, the inferior margin somewhat less strongly curved; beaks somewhat behind the middle, narrow, almost pointed, projecting well over the hinge margin; surface polished, with very slight, somewhat irregular striæ, and one or two rest-lines; color whitish to straw, with a few narrow alternating narrow zones which are glassy transparent; hinge short, little over one-half the length of the mussel, curved, moderately stout; plate somewhat broad; cardinals small, slight, high up on the plate, the right moderately curved or nearly straight, its posterior part a little thicker, grooved to somewhat bifid; the left both slightly curved, of nearly equal lengths, or the posterior somewhat larger; laminæ short, in the right valve the inner both with cusps occupying their entire length, pointed, bent upward, the anterior especially so, and markedly concave on its upper face, somewhat spoon-shaped, the outer ones both small and short; in the left valve both with cusps very abrupt, almost spine-like; ligament rather short and moderately thick. Long. 4.2; alt. 3.7; diam. 3.4 mm.; long. 4.2; alt. 3.6; diam. 2.8 mm.

Soft parts colorless or light yellowish (in preserving fluid). Almost every specimen, even barely half-grown, contains a number of nepionic young.

Habitat: Upsilon Lake, Turtle Mountains, North Dakota, in mud and sand, water about one foot deep. Collected by Mina L. Winslow, July 15, 1919. Type C. M., No. 9160 and seq.; paratypes in the Museum of Zoölogy, University of Michigan.

This *Pisidium* is so characteristic and so greatly different from others that there can be no question about its representing a distinct species, apparently not seen or noticed before. Probably it is of northern distribution. The specimens, several score, ranging from quite young to full-grown, are remarkably uniform, in regard to size, shape, and color. However, a few have a small, but well-marked, sharp scutellar angle at the junction of the upper margin and the supero-anterior slope, as frequently seen in some other forms—*e. g., scutellatum, sargenti, ovum,* and typical *elevatum.*

8. *Pisidium notophthalmi* n. sp. Mussel minute, elongate, subequi-

partite, little oblique, moderately inflated; outlines nearly elliptical, with the superior margin rather long, nearly straight, the supero-anterior slope slightly marked, the posterior margin rounded or subtruncate, inferior moderately curved; beaks slightly behind the middle, rather small, rounded, not much projecting over the hinge-margin; surface shining, with very fine, slight irregular striæ almost obsolete over the beaks; color whitish, apparently bleached, and probably glassy colorless when fresh; shell thin, hinge rather long, slight, plate very narrow; cardinals small, the right slightly curved, its posterior part projecting cusp-like, somewhat thicker and slightly grooved, the left both short, nearly parallel, the anterior close to the hinge-edge, somewhat pointed; laminæ slight, the inner of the right valve with their cusps somewhat pointed and abrupt, the outer ones long, one-half to three-fourths the length of the outer, the anterior with a small, pointed, distal cusp; the left ones with their cusps distal, pointed, abrupt; ligament rather short, slight, but occupying nearly the whole thickness of the plate. Long. 2.3, alt. 1.8, diam. 1.3 mm.; long. 2, alt. 1.5, diam. 1.3 mm. (apparently mature).

Habitat: Wild Cat Lake, Skokomish Valley, Mason County, Washington. Collected by Mrs. Helen T. Gaige in 1919, and sent for examination by Miss M. L. Winslow. The specimens were taken from the digestive tract of a salamander, *Notophthalmus torosus,* and are all "dead shells," bleached, mostly valves, but a large part otherwise in good condition, with the periostracum and the hinges intact. The mussels were evidently abundant at the place; of nearly three hundred, all, except one, a young shell of *Pisidium* sp. ?, were of this same species, from nepionic young, some still in the parents, to apparently full-grown, or nearly so, and fairly uniform. The hinges show some variation: in some specimens the outer laminæ of the right valve are rather short; and in some the cardinals of the left valve are more oblique; and occasionally the posterior is rudimentary.

The only *Pisidium,* which *P. notophthalmi* resembles, is *tenuissimum* (exceptionally small forms), but the mussel is more elongate and less oblique, and the hinge is different.

Type in the C. M., No. 9229; paratypes in the Museum of Zoölogy, University of Michigan.

9. *Pisidium orcasense* n. sp. Mussel of medium size, subequipartite, barely oblique, moderately and evenly inflated; outlines short oval

to nearly elliptic without any angles, except a slight, rounded one at the scutum, supero-anterior slope not, or little, marked, anterior end rather broadly rounded, posterior end rounded to subtruncate; beaks slightly behind the middle, broad, rounded, moderately projecting over the hinge-margin; surface shining to somewhat dull and with a slight silky gloss, under the microscope distinctly rugulose, with fine, irregular, somewhat sharp and crowded striæ and a few slightly marked rest-lines; color pale corneous, shell thin, translucent; hinge about three-fourths the length of the mussel, slight, with a somewhat broad plate; cardinals rather small and slight, well up on the plate, the right curved with its posterior part bifid, a somewhat narrow, but deep, excavation below it; left anterior somewhat oblique, curved to angular, its edge pointed, posterior oblique, slightly curved, "covering" only a small part of the anterior; laminæ slight, projecting inward but little, the right inner both with somewhat proximal, small, pointed cusps, the outer both short and small; left both with the cusps about median, small, pointed, somewhat abrupt; ligament rather short and thick. Long. 4.3; alt. 3.6; diam. 2.6 mm.

Habitat: Orcas Id., San Juan County, Washington. Collected by Carl C. Engberg in 1919. Type C. M., No. 9242 and seq.; paratypes in the collection of Mr. Engberg.

There were about fifty specimens in the lot, ranging from quite young to apparently mature; one mussel opened contained six nepionic young 1.5 mm. long. Some specimens are slightly more elongate, with the surface more polished, whitish to straw-color, but probably not distinct.

At first glance this *Pisidium* does not show very strongly marked features, but upon closer examination it proves peculiar as to its shape and hinge. It may be noted that the right cardinal is placed close to the edge of the valve (nymph), and this is in accord with the shortness of the left posterior, only its posterior (inferior) part being developed.

As to shape, *P. orcasense* is similar to *P. pusillum* Jenyns from Europe; whether they may be really related to each other must be ascertained later.

10. *Pisidium prognathum* n. sp. Mussel of rather small size, oblique, little elongate, rather well and evenly inflated, anterior part slightly longer and directed downward; superior part rather long,

curved, supero-anterior slope slightly curved, anterior end well below the median line, rounded angular, posterior margin subtruncate postero-anteriorly to rounded, passing into the inferior without any angle; beaks somewhat posterior, rather small, rounded, little elevated; surface dull glossy, with very fine, barely noticeable, irregular striæ, and two or three slightly marked rest-lines; color yellowish corneous, shell thin, translucent to transparent; hinge somewhat short, about three-fifths the length of the mussel, curved, rather slight, plate rather long, narrow; the right cardinal rather long, moderately, and regularly curved, its posterior part slightly thicker and grooved, both left cardinals a little oblique, rather long, nearly parallel, slightly curved, the posterior passing over the anterior for about two-thirds of its length; the right inner laminæ both have the cusps rather distal, pointed, not very abrupt, both the outer laminæ are small and short, or the posterior about one-third the length of the inner, both left laminæ with their cusps distal, very abrupt, spine-like, with the crests somewhat rounded or truncate, inclined distalward; ligament moderately long and thick. Long. 3.2; alt. 2.7; diam. 2 mm.

Soft parts apparently of a yellowish or reddish tinge, as seen in dried specimens. One mussel was almost completely filled with about twenty-two nepionic young, about 0.8 mm. long, and in others the young could be seen through the transparent shell.

Habitat: A small swamp near Quamishan, Vancouver Island, British Columbia, associated with the following, all plainly identical, with slight variation as to size and shape.

11. *Pisidium pilula* n. sp. Mussel subequipartite, somewhat elongate, strongly inflated, globular; outlines of the valve-edges oval to elliptical, supero-anterior slope barely or not marked; beaks somewhat posterior, narrow, calyculate, rather well elevated and somewhat inclined backward; surface shining, with striæ very fine and slight, shallow, irregular; color pale corneous, lighter inclining to straw-color along the margins; shell thin, translucent; hinge curved, slight, plate short, narrow; cardinals quite small, short, the right slightly curved, with the posterior part abruptly much thicker, bifid; left both comparatively very short, far apart, the anterior on the edge of the hinge, with its crest pointed, the posterior oblique, barely curved, not extending over the anterior; the right inner laminæ both with the beaks about median, small, pointed, bent upward, the outer anterior

quite small, vestigial, posterior nearly half as long as the inner, connate with it proximally; the left both with their cusps about median, small, very abrupt, nearly spine-like; ligament rather short and thick. Long. 3.3; alt. (over beaks) 2.9; diam. 2.7 mm.

Habitat: Small swamp near Quamishan, Vancouver Island, British Columbia. Collected by A. W. Hanham, sent for examination by S. S. Berry, 1919. There were only four specimens in the lot, associated with the preceding species and *P. columbianum*. They are plainly distinct and show only slight differences of shape between themselves. The mussel is so strongly and evenly inflated that a transverse section behind the beaks would be circular, or the diameter may even surpass the dorso-ventral dimension. That the beaks are calyculate is possibly due to some influence of the habitat, and specimens from other places may not show this feature. Only one specimen was opened, but its hinge appeared to be normal. In shape they are somewhat like forms of *P. medianum* Sterki, but the beaks are inclined backward, and the hinge is different. Type in the C. M., No. 9261.

12. *Sphærium declive* n. sp. In the Preliminary Catalog of the North American Sphæriidæ, p. 433, it is stated that a form of *Sphærium* was doubtfully referred to *aureum* Prime.[1] With more materials coming in, it became evident that the form was at least a well-marked subspecies, which I have named *declive*. A large number of good specimens from the Sheyenne River, North Dakota, collected by members of the University of Michigan in the summer of 1919, are evidently the same, and showed conclusively that this *Sphærium* is different and distinct from *aureum*.

The mussel is less elongate, the supero-anterior slope is more marked and steeper, the posterior margin is truncate or subtruncate at nearly right angles; both ends are more angular[2] and more ventral; the beaks are somewhat anterior and inclined forward, and markedly narrow in the center, as is especially noticeable in half-grown and adolescent mussels, moderately large, somewhat broad, and not so

[1] As described and figured by T. Prime in Mon. Corb., p. 35, and shown in the rather poor specimen (valves) in his collection, not designated as type; origin: "Lake Superior?".

[2] Old specimens are often of more rounded outlines, and less characteristic; the same is true with almost all Sphæria of this group (*Cyrenastrum*).

greatly prominent in the full-grown; the sulci are somewhat coarse and rather irregular to slight and almost obsolete; the color is lighter or darker grayish corneous. The hinge is somewhat more curved, the posterior laminæ being at a noticeable angle to the plate. It should be added that mussels taken for *aureum* are regularly and evenly rounded-inflated, while in *declive* the disks—*i. e.*, the middle part of the valves—are somewhat flattened. Long. 14.5; alt. 11.5; diam. 8.8 mm.

Typical specimens, well representing the species, are C. M., No. 9140, from the Sheyenne River, near Tolina, North Dakota, collected by Mina L. Winslow, July 26, 1919; other specimens of the same lot are in the collection of the Museum of Zoölogy, University of Michigan. There are also numerous specimens from Deuel County, South Dakota, collected by W. H. Over in 1896; Bates Creek, C. M. Nos. 5212, 5315, etc.; and a small creek near Clear Lake, C. M. No. 5133, etc.; the former are larger, with heavier shells and hinges; long. 16.4; alt. 12.5; diam. 10.5 mm.

XIV. STUDIES IN THE GENUS LACTUCA IN WESTERN PENNSYLVANIA.

By O. E. Jennings.

(Plate XXXIII.)

During seventeen years of botanizing in the region of Pittsburgh the writer has been annually impressed with certain peculiar characteristics of some of the species of *Lactuca* occurring here. Various collections and very numerous observations in the field have served to confirm the suspicion that certain of the species, as they occur in this region, possess characteristics in part different from the typical forms of the species as described in current botanical literature. To render the identification of the local forms more exact, and thus to aid in better establishing their geographical limits, the new varieties herein named are proposed.

Lactuca spicata variety **aurea** var. nov.

There grows abundantly in uncultivated grounds and neglected lots and fields throughout Allegheny and adjacent counties a tall *Lactuca* with tawny or sordid pappus, which generally agrees quite well with *Lactuca spicata* (Lamarck) Hitchcock, except that the plant is more robust and the flowers are bright lemon-yellow, often withering to bright orange. Among thousands of the plants observed in various parts of the region all had yellow flowers, with the single exception of a plant with very light-colored flowers, suggesting albinism.

As first described, in Lamarck's Encyclopédie, in 1789, *Sonchus spicatus* from South Carolina had purplish flowers (*"Les fleurs sont purpurines"*),[1] and in DeCandolle's Prodromus, in 1838, Section II, under *Agalma* of the genus *Mulgedium*, it was characterized as follows: *"Pappus sordescens. Involucrum calyculatum aut calyculato-imbricatum. Cor. cœruleæ aut purpureæ."* And under this section was

[1] Lamarck, J. B. A. P. M., Encyclopédie Méthodique, Botanique, III, 1789, p. 401.

described *Mulgedium leucophæum "ad margines sylvarum Amer. bor. à Novâ-Angliâ ad Virginiam* (Pursh), *ad Lacum Huron* (Hook.)."[2]

In an examination of about twenty descriptions of *Lactuca spicata* as placed by various authors under the genus *Sonchus, Mulgedium,* or *Lactuca,* only four references were found giving the color of the flowers as yellow or yellowish. The descriptions in by far the greater number of the manuals and floras of the eastern United States have been drawn very largely from material collected and studied along the eastern coastal regions; this being, of course, especially true of the earlier systematic works, when practically nothing was known of the flora in or beyond the Appalachians. In this connection it is of interest to note that in some of the earlier systematic works where *Lactuca spicata* was known only from the region quite closely adjacent to the Atlantic coast the plant is always described as having blue or white flowers.[3] As the species became somewhat better known, and its known range was extended into the interior, a few of the descriptions indicated the flowers as ranging in color from blue to yellow,[4] while Wood, in his valuable Class-Book, described the flowers only as "yellowish."[5]

A further examination of the evidence furnished by the various "floras" and "manuals" indicates that in the New England States and along a comparatively narrow strip bordering the Atlantic coast the flowers of *Lactuca spicata* are blue to white, while to the southwest and west the flowers become more or less completely yellow. That the line of demarcation between these regions is perhaps quite sharp is not unlikely. In the more recently published Flora of Philadelphia and Vicinity[6] the flowers are referred to as blue to white, while in Darlington's *Flora Cestrica* we have "Florets *pale blue,* or *ochroleucous.*" Small and Carter in their Flora of Lancaster County [Pennsylvania] say for *Mulgedium spicatum:* "ligules white, yellowish, or bluish."[7] From the foregoing and from such facts as the

[2] De Candolle, A. P., Prodromus Systematis Naturalis Regni Vegetabilis, VII, 1838, p. 250.

[3] Eaton's Manual, Chapman's Flora, Pursh's Flora, Torrey's Flora, N. Y., etc.

[4] Noll, H. R., Flora of Pennsylvania, 1852; Small, J. K., Flora of the Southeastern U. S.; Darlington, Wm., Flora Cestrica, 1853.

[5] Wood, A., Class-Book of Botany, 1880, etc.

[6] Keller, I. A., and Brown, S., Handbook of the Flora of Philadelphia and Vicinity, 1905.

[7] Small, J. K., and Carter, J. J., Flora of Lancaster County, 1913.

writer has been able to ascertain from his own studies in the field and herbarium the belief has become quite strong that we are dealing here with two distinct forms, whose relationships are probably best indicated as those of species and variety, the latter limited to the interior in its geographical distribution.

The writer has had the privilege of examining the collections of *Lactuca spicata* in the herbaria of the Philadelphia Academy of Natural Sciences, the National Herbarium at Washington, and the Ohio State Herbarium at Columbus, and as far as could be determined from the specimens, just as from the numerous specimens in the Carnegie Museum, the color of the flowers was yellow in all plants collected in or to the west of the Appalachians. The only blue-flowered specimens seen were from the region distinctly to the east of the mountains.

The variety *aurea,* as it occurs in the Pittsburgh region, is:

Biennial, perhaps rarely annual: stems stout, striate, glabrous, green to brownish, often somewhat glaucous, about 1 to 5 meters high, sometimes 2 cm. or more in diameter at the base, erect, strict, unbranched up to the inflorescence; leaves in general outline obovate, acuminate, more or less deeply runcinate-pinnatifid and lobed, more or less sinuately toothed, often doubly so, the leaves reaching a length of 3 dm. or more, the terminal lobe being usually more or less unlobed and equilaterally triangular and comprising one-third to one-half the length of the leaf; below the lamina narrowing to a widely margined petiole and more or less auriculate-clasping base, the leaves usually pubescent on the veins and mid-rib beneath; the inflorescence forming an erect, rather densely spicate panicle, the upper leaves narrowing to lanceolate-acuminate bracts with auriculate-clasping bases; pedicels rather stout, divaricate to ascending, with two to four minute linear-lanceolate bracts; heads numerous, in flower about 1 to 1.5 mm. broad, the involucre 9 to 12 mm. high, oblong-cylindric, the principal bracts of an equal length and from a little shorter to as long as the pappus of the ripe achenes, linear-lanceolate, sub-acute to obtuse, whitish- or scarious-margined, the outer bracts few, much shorter, all glabrous, the ligules yellowish-green or sometimes golden, soon withering; achenes oblong, about 1.5 mm. wide by 4.5 to 5 mm. long, flat, quite curved usually, the middle portion distinctly longitudinally striate, the whole surface rugose with minute short transverse ridges, grayish-

brown, but much mottled with blotches of dark brown, at the apex narrowing to a short, stout beak about 0.5 mm. long, pappus about 5 mm. long, tawny, minutely barbed upwardly. Flowers in September to October, rarely in late August.

In various soils, mostly in moist fertile soils; often an abundant weed in temporarily idle cultivated ground. Specimens have been examined from the following regions: central and western Maryland; central and western Pennsylvania; western and northern West Virginia; and from localities representing practically all portions of Ohio. The color of the flowers, so far as could be determined from the herbarium specimens, was invariably yellowish in all specimens collected in or west of the Appalachians.

The types, one sheet as to rosette-leaves and the other as to flowering stems, flowers, and seeds, are deposited in the Pennsylvania Herbarium of the Carnegie Museum. The types were collected on an idle plot of ground at the corner of Forbes Street and Woodlawn Avenue, Pittsburgh, Pennsylvania, October 2, 1905, by O. E. Jennings and Grace E. Kinzer.

The variety *integrifolia* Gray, as described under *Lactuca leucophæa,* and having "leaves undivided (simulating those of *L. acuminata,* but sessile), or the lowest sinuate-pinnatifid," was founded upon specimens from "Ohio, *Lea.* Canton, Illinois, *Wolf.*" The type of Gray's variety *integrifolia* is thus quite likely an entire leaved form of the variety *aurea* and its disposition would best be as follows:

Lactuca spicata var. **aurea** forma **integrifolia** (Gray) comb. nov.

Lactuca leucophæa var. *integrifolia* GRAY, Synoptical Flora of North America, I, Part 2, 1886, p. 444.

Some of the specimens of *L. spicata* var. *aurea* collected in the Pittsburgh region show quite evident tendencies toward the entire-leaved form, and in the State Herbarium at Columbus, Ohio, there is a specimen collected in Holmes County, Ohio (Kellerman), and another collected in Defiance County, Ohio (Fullmer), in central and northwestern Ohio, respectively, that are clearly typical of forma *integrifolia.*

Lactuca canadensis var. *spinulosa* var. nov.

The form of wild lettuce which becomes so abundant in neglected upland meadows in the Pittsburgh district appears not to be the same as that which has long passed as *Lactuca canadensis*. As Linnæus characterized it, at least under the synonymy which he quoted (Species Plantarum II, p. 796), *Lactuca canadensis* does not have spinulose midribs, and in the keys and descriptions in the current manuals of today it is usually characterized as distinctly glabrous and with beak and achene of equal length. Gray, however (Synoptical Flora of North America, 1886, p. 442), says "Midrib naked or rarely some sparse bristles," and he there mentions also that the achene is "rather longer than the beak," a characteristic of the plant as it occurs in western Pennsylvania, but hardly in accordance with the treatment given it in most of the current manuals.

A typical specimen collected by the writer, July 21, 1918, in a neglected hill-top meadow about one mile north of Glenshaw, Allegheny County, Pennsylvania, altitude about thirteen hundred and twenty feet above the sea, may be described as the type of the new variety:

Lactuca canadensis variety **spinulosa** var. nov.

Stem erect, rigid, but moderately slender, smooth, tinged and speckled with purple, rather densely leafy, abundantly branching above into an open panicle of broadly oblong outline. Leaves about 10–15 cm. long, about two-fifths as wide, pale beneath, sagittate-clasping, the lower narrowed into winged petioles, the upper sessile, all more or less runcinately pinnatifid and somewhat spinose-dentate, the terminal lobe elongated, most of the lobes broadening above the base and acuminate, the lower side of the midrib, especially in the basal leaves, furnished with rather weak spinose hairs. Heads numerous, the involucre 10–12 mm. high, the lower short bracts purplish, the inner long ones scarious-margined; the flowers about 14–17 in number, light yellow; the achenes about 3 mm. long, oblong-oval, brown to blackish, transversely rugulose, thin, the margin about two-thirds as wide as the body of the achene, the beak slender and about 2 mm. long, the pappus soft and shining white, about 6 mm. long.

In richer and moister soil the plant may become at least twice as

large as the specimen described, but such specimens are not common, the larger plants of rich shaded and moist slopes being in the Pittsburgh region almost invariably the entirely glabrous and more robust *Lactuca canadensis* instead of the variety *spinulosa*. The variety is the common weed of the hay fields in this region, while the species itself is the rarer plant of woodlands and thickets.

EXPLANATION OF PLATE XXXIII.

FIG. *A*. Rosette-leaves of *Lactuca spicata* var. *aurea*. One-fourth natural size.

FIG. *B*. Stem and leaves of *L. spicata* var. *aurea*. One-fourth natural size.

FIG. *C*. Branch of inflorescence of same plant. One-fourth natural size.

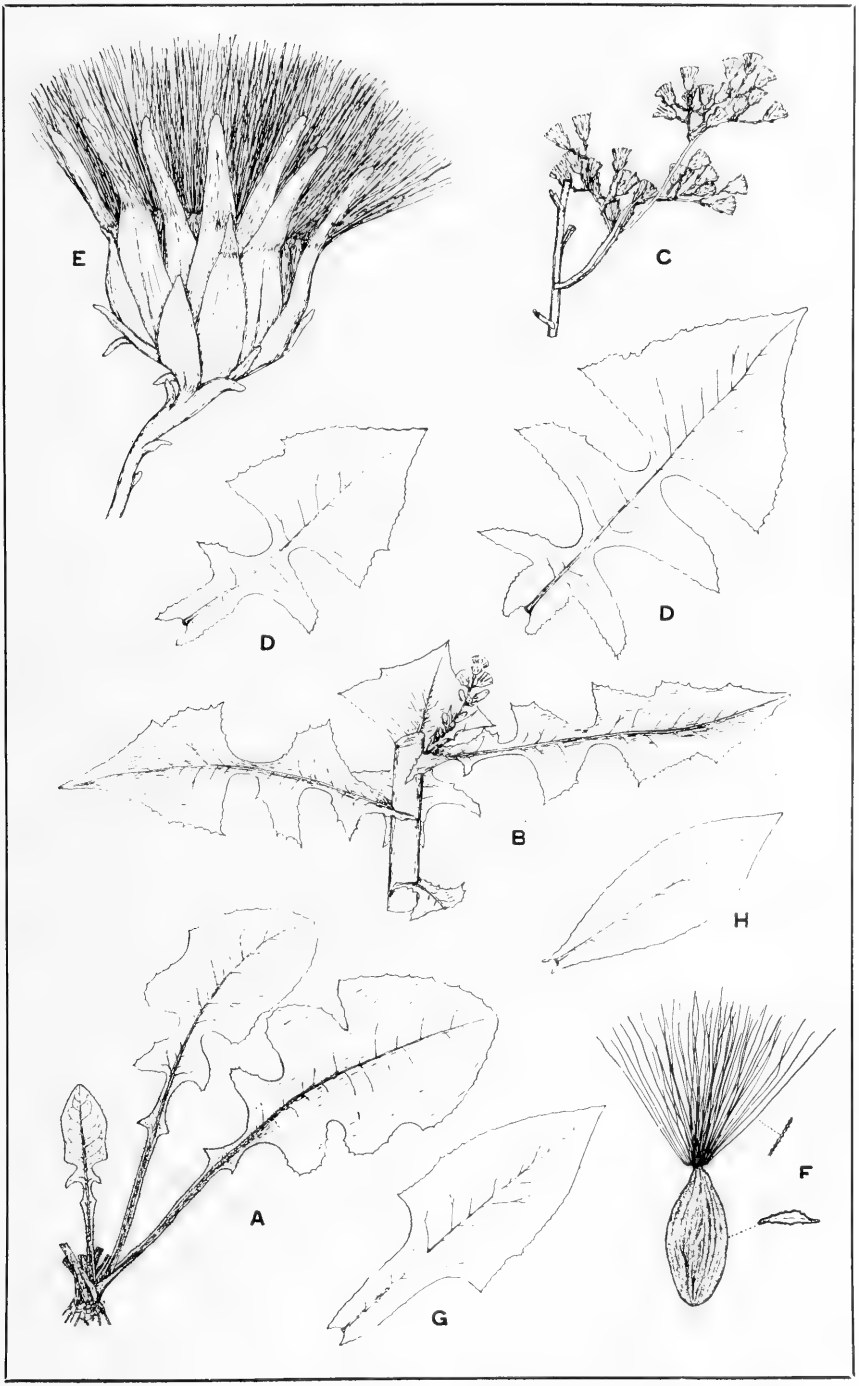
FIG. *D*. Stem-leaves from lower part of stem of a smaller plant than was drawn in fig. *B*. One-fourth natural size.

FIG. *E*. Head of *L. spicata* var. *aurea* with ripe achenes. Three and one-half times natural size.

FIG. *F*. Ripe achene from head in fig. *E*, drawn at same scale.

FIGS. *G* AND *H*. Stem-leaves from plants of *L. spicata* var. *aurea* forma *integrifolia*. One-fourth natural size.

(All figures were drawn from specimens collected in Pittsburgh, Pennsylvania, Oct. 2, 1905, by O. E. Jennings and Grace E. Kinzer.)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ANNALS

OF THE

CARNEGIE MUSEUM

VOL. XIII. NOS. 1-2.

October, 1920.

For sale by Messrs. Wm. Wesley & Sons, 28 Essex St. Strand, London, England; Maruzen Company, Ltd., 11–16, Nihonbashi Tori Sanchome, Tokyo, Japan; and at the Carnegie Museum, Schenley Park, Pittsburgh, Pa., U. S. A.

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Publications of the Carnegie Museum Serial No. 110

ANNALS

OF THE

CARNEGIE MUSEUM

VOL. XIII. NOS. 3-4.

March, 1922

For sale by Messrs. Wheldon & Wesley, Ltd., 38 Great Queen Street, Kingsway, London, W. C. E., England; Maruzen Company, Ltd., 11–16, Nihonbashi, Tori-Sanchome, Tokyo, Japan; and at the Carnegie Museum, Schenley Park, Pittsburgh, Pa., U. S. A.

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